DEPARTMENT OF OCEAN ENGINEERING
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS 02139

USE OF MULTIPLE ATTRIBUTE TRADEOFF ANALYSIS IN SHIP DESIGN

by

CHRISTOPHER JOHN SETZER

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SM(NAME)

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CHRISTOPHER JOHN SETZER

B.S.E.E., Purdue University
(1980)

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ABSTRACT

A methodology for evaluating a large number of design concepts with multiple and conflicting attributes is presented. The methodology is called Multiple Attribute Tradeoff Analysis. It was developed at the Massachusetts Institute of Technology for large utility companies as a means of system design in the face of uncertainty. The methodology is adapted for use in the ship design process. A case study, exploring machinery plant combinations, is presented to validate the analysis. The methodology can be a useful tool for designers, research and development managers, and decision makers.

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SYMBOLS AND ABBREVIATIONS

AAW	Antiaircraft Warfare
ASW	Antisubmarine Warfare
DISP	Full Load Displacement
INTVOL	Total Internal Volume
KW	Kilowatts
R/M/A	Reliability / Maintainability / Availability
SHP	Shaft Horsepower
Vs	Maximum Sustained Speed
W200	Weight of Propulsion Plant
W300	Weight of Electrical Plant

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Both engineering and commitment decisions must be made in the design of a naval combatant ship. Engineering decisions are normally made by working level engineers at the system or subsystem level. They are based primarily on engineering principles. For example, a certain size beam made out of mild steel will either support the projected loads or it will not. On the other hand, commitment decisions are often driven by higher level programatic factors as well as political considerations. These decisions are usually made many levels up the chain of command from the working engineer. System cost effectiveness as well as personal preference and political acceptability, play a major role in the final analysis. For example, the decision to commit to a high risk innovative design like a gas turbine propulsion plant with electric drive versus a gas turbine plant with mechanical drive can be greatly influenced by the past performance of the mechanical drive system. Although there are two distinct types of decisions, they are highly interactive and can greatly influence one another.

Figure 1.1 illustrates the interaction of the engineering and commitment decisions. Throughout the design process, a certain amount of engineering must be done to support a commitment decision. On the other hand, certain

commitment decisions must be made to support the engineering effort. A definite balance between engineering and commitment must be established and maintained in order to keep the design process alive and moving forward in a normal manner. In naval ship design, a commitment decision will normally slow the process for longer periods of time.

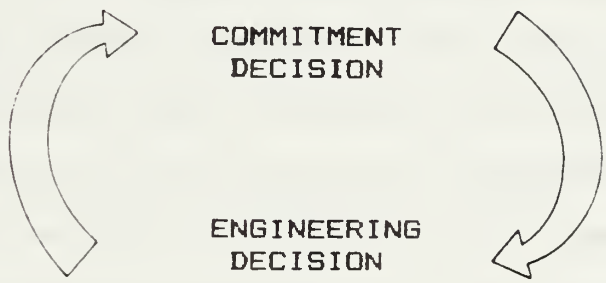


FIGURE 1.1

INTERACTION OF ENGINEERING AND COMMITMENT DECISIONS

There are several key factors which complicate the commitment decision. First, large numbers of systems and subsystems are required in a ship. Second, there is a high degree of diversification in the systems and subsystems. Third, there are numerous mission requirements of major importance. Fourth, there is a very high degree of integration between all aspects of a ship. Fifth, the unit cost of a ship is high, about a billion dollars per copy. Sixth, there is the low production output, only 20 to 30 ships of a

class. Finally, the useful life expectancy of the ship is 20 to 30 years. Given these key factors, it is easy to see why a decision maker would hesitate to commit to one concept over another and would want the maximum amount of information possible before making a commitment decision.

The primary sources of the information made available to the decision maker are tradeoff studies. These studies are conducted at all levels, from system components through subsystem and system concepts to whole ship impact studies. While the advent and use of computers has enhanced the ship design process, it has also greatly increased the amount of information to be absorbed by the decision maker. This large volume of information has resulted in many ideas and theories on how to best assemble and analyze the data to precipitate a decision. However, before proceeding with a discussion of the current decision methodology used in ship design, the ship design process as a whole will be briefly reviewed.

1.2 THE SHIP DESIGN PROCESS

Three key areas of the ship design process are its iterative nature, stages of development, and decision methodology. The iterative nature and stages of the design process will be briefly reviewed while the decision methodology will be discussed in Chapter 2.

The iterative nature of the ship design process is illustrated in Figure 1.2. As the design progresses around the spiral, additional systems and subsystems are included in

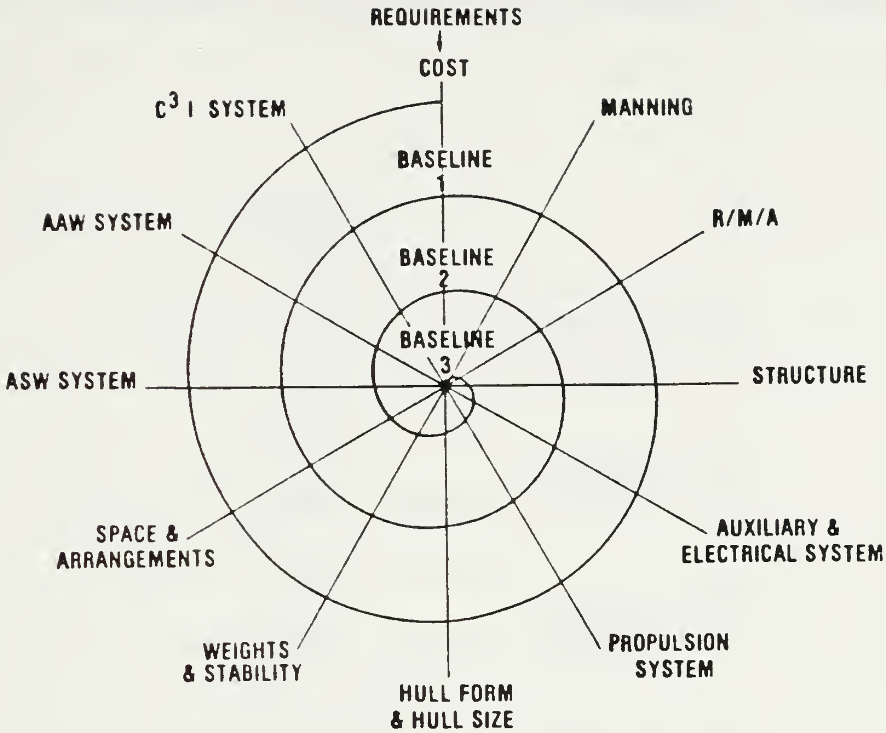


FIGURE 1.2

THE ITERATIVE NATURE OF SHIP DESIGN

the design. The second and third iterations indicate that as additional detail and number of systems are added, the design must be rechecked to ensure that a balanced design has been achieved. Because each system and subsystem must be balanced before it is integrated into the overall design, each branch can contain several similar spirals. Also, as each system or subsystem is modified, the whole design must be rebalanced to get a true indication of the full impact of the the change.

The ship design process will flow through various

stages of development as outlined in Figure 1.3 and explained below.

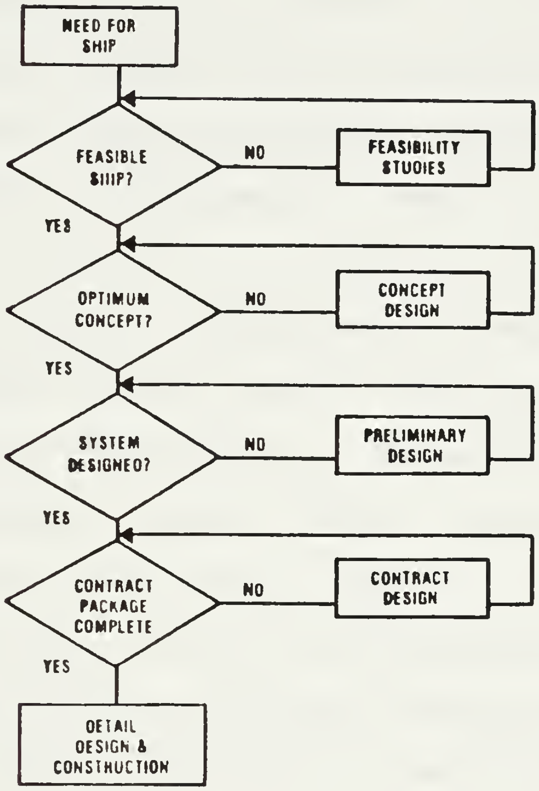


FIGURE 1.3

LOGICAL FLOW OF SHIP DESIGN PROCESS

- Need For A Ship: Before the design process is really initiated, the need for a new ship has to be established. This need could be justified by the retirement of old ships, the introduction of a new capablity, the intro-

duction of new technology, or the requirement to meet a new mission that is beyond the capablity of the present fleet.

- Feasibility Studies: The main objective of the feasibility studies is to identify at least one feasible concept which meets all the top level requirements, in other words, a concept that is affordable, technically feasible, meets all mission requirements, and is politically acceptable.

- Concept Design: The purpose of concept design is to select the system concept which is the best overall way to meet the top level requirements. Therefore, each concept must be designed to enough detail to conduct a tradeoff analysis. However, the level of detail in concept design does not require all systems and subsystems to be selected. For example, the use of gas turbines versus steam propulsion can be made, without the type of reversing mechanism being selected.

- Preliminary Design: Design and engineer the system concept selected during concept design. Special emphasis is given to the interfaces between subsystems and systems as well as to high risk areas of the concept design.

- Contract Design: Complete the ship design in enough detail to write a business contract.

- Detail Design and Construction: Produce the working drawings and engineering products required to build, test, and deliver the ship.

During all phases of the design process, numerous

engineering and commitment decisions are made. As the nature of the decisions change, the type and amount of information required to support the decisions also change. For example, as the design process moves downward from the feasibility studies through contract design, the number of alternative subsystems and systems decreases while the level of detailed analysis increases. If a decision methodology is to be applicable to all phases of the design process, it must be flexible enough to accommodate the changing nature of the information to be analyzed.

CHAPTER 2

CURRENT DECISION PROCESS

2.1 INTRODUCTION

The methodology of decision making in ship design must be able to address several key issues. The issues are not unique to ship design and can be found in any complex system [1]. However, the number and names of the issues may vary slightly depending on the type of system. The key issues of a decision methodology used in ship design are outlined below.

(1) Multiple Objectives - In a complex system, there are competing and often contrasting objectives. Every combat ship has a minimum set of top level requirements or objectives that it must meet. These requirements may be ship characteristics such as maximum sustained speed, minimum range at a given endurance speed, maximum displacement, cost limitations, and crew size. Also, a combat ship must perform multiple primary and secondary missions such as antisubmarine warfare, antiaircraft warfare, and support of tactical data communication links. The multiple objectives are incorporated into the design through the use of systems and subsystems.

(2) Multiple Decision Makers - In a complex system design, several different organizations can control different critical aspects of the design. The decision level structure for naval ship design is illustrated in Figure 2.1.

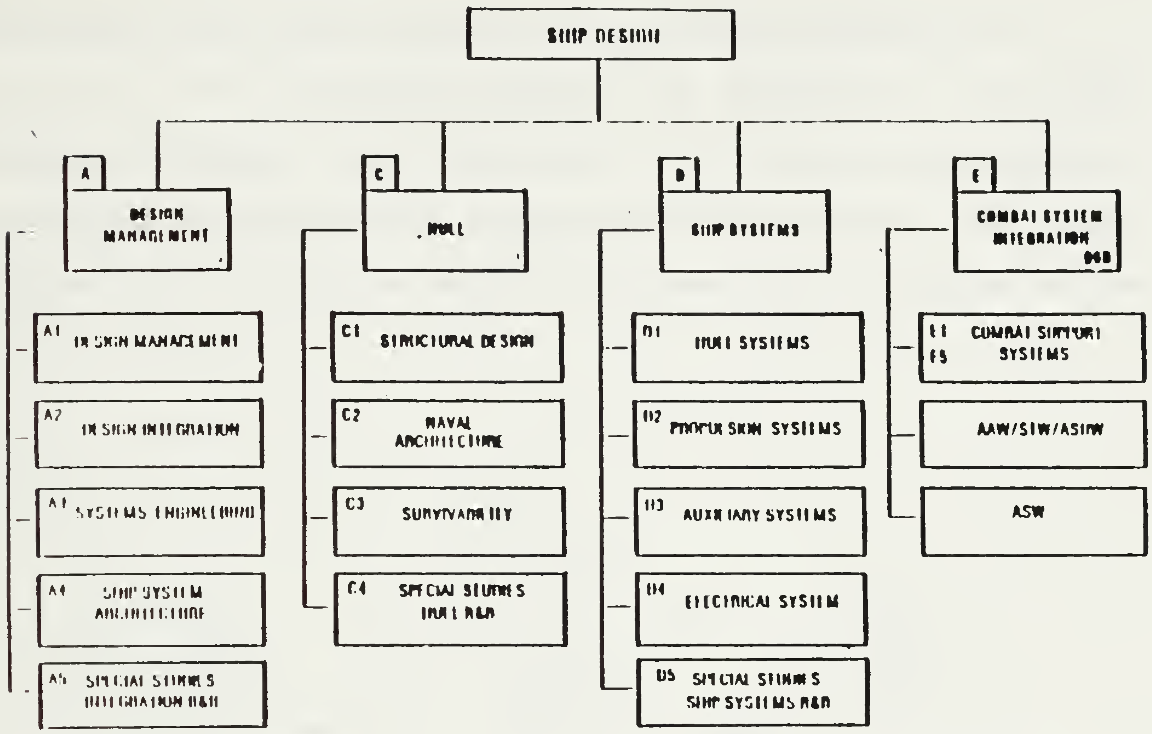


FIGURE 2.1

SHIP DESIGN / DECISION STRUCTURE

As can be seen, the Navy uses a matrix organization and different aspects of the design are controlled by different codes. Of course, each code wants a little bigger piece of the ship than the space and weight limitations of a balanced design will allow. Also, each code tends to have a different perspective of the relative importance of various systems, that is, their systems are the most important. Finally, the functional codes feel they are in the best position to make

commitment decisions and not the project organization.

(3) Global Effects of Decisions - In ship design, systems and subsystems are highly integrated and cannot be uncoupled from one another. This point is illustrated by the design spiral in Figure 2.2. A change in one

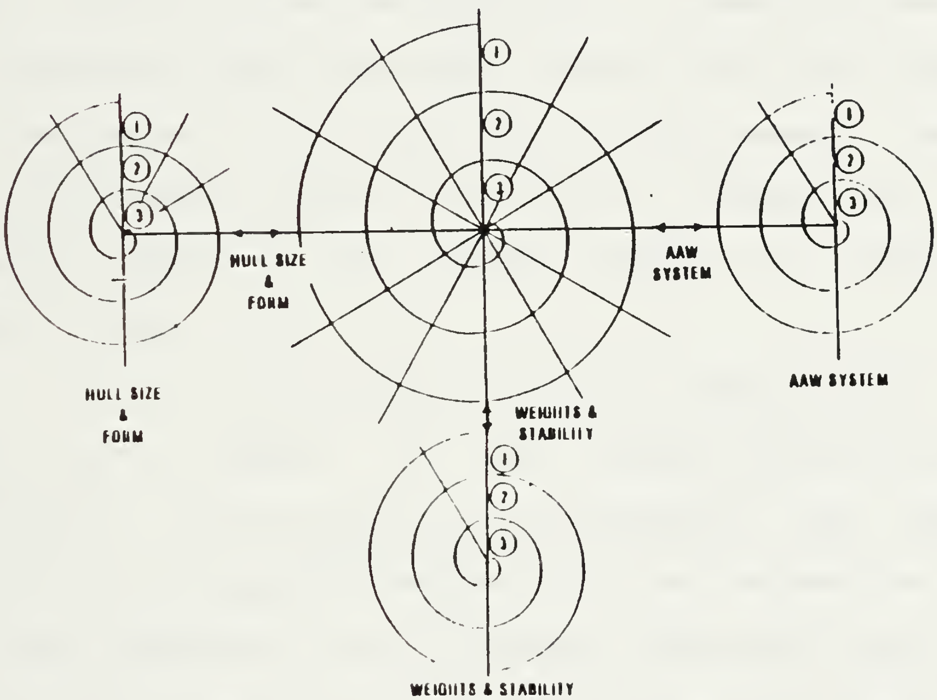


FIGURE 2.2

THE ITERATIVE NATURE OF SHIP DESIGN

aspect of a ship design can produce secondary and tertiary changes in every aspect of the design.

(4) Uncertainty - In most cases it is not possible to completely define the impact of choosing one system over another. This is particularly true if one system is new or innovative. The result is some degree of uncertainty associated with the performance, operability, reliability, integration and/or cost of the system chosen.

(5) Risk - The attitudes of the decision makers towards risk are important. If there is some degree of uncertainty associated with a system selection, then there is some degree of risk involved with the system. The amount of risk a decision maker is willing to accept can have a dramatic effect on the overall design of a ship or any complex system.

(6) Acceptability of the Design - The acceptability of a design can often depend highly on personal preference. A ship design which represents long term cost savings can be rejected because it is more expensive in terms of today's dollars. Since Congress controls the military budget and funding of ships, political acceptability of a design can have a major impact on its ability to survive.

All six key issues combine to form the general environment in which design decisions are made. To further complicate the decision process, the people making decisions today can transfer and be gone tomorrow. New people filling old positions may have different views of what is important or what constitutes a good design. The result is that the whole aspect of a design can basically change overnight.

Therefore, any decision methodology used must be flexible and adaptable to the current environment and current decision maker.

2.2 CURRENT DECISION METHODOLOGY

The decision methodology widely used in ship design is a simple utility function. Decision makers are presented with a few well screened alternatives for the final decision. The relative "goodness" of each attribute of the alternatives is usually represented by a scalar value or a ranking of poor, fair, good, or best. The attributes, presented along with the weighting factor of each attribute, are preselected to reflect the preferences of the decision maker.

The following example was taken from one of the briefs given on the Navy's recent destroyer development project, DDG-51. Table 2.1 is a list of the design attributes to be considered with a weighting factor for each attribute. The weighting factors are a reflection of the design philosophy of the project. Table 2.2 is a sample of how each attribute is ranked for each concept under consideration. Each concept is assigned a grade based on its relative standing among all the concepts. The grade is then multipled by the weighting factor to give each concept an overall score for the attribute. This procedure is done for all the attributes being considered. Table 2.3 provides an evaluation summary and total score for each concept. The results were also presented with each concept being assigned a ranking of poor,

Design Attributes Considered

• COMBAT CAPABILITY	10
• SHIP ACQUISITION COST	10
• SHIP DISPLACEMENT	5
• ENERGY CONSERVATION	5
• MANNING REDUCTION	5
• PASSIVE SURVIVABILITY	5
• BLOCK UPGRADE / FUTURE GROWTH FLEXIBILITY	5
• OPERABILITY	5/3
• AVAILABILITY	5/3
• RELIABILITY / MAINTAINABILITY	5/3
• HABITABILITY	2.5
• MINIMUM RISK	2.5
• STANDARDIZATION	2.5

TABLE 2.1

DESIGN ATTRIBUTES AND WEIGHTING FACTORS

SHIP DISPLACEMENT (WF 5.0)

(1) DD08 ESTIMATE

(2) ESTIMATE BASED ON MARGINAL FACTORS

CONCEPT	FULL LOAD DISPLACEMENT (M TONS)	GRADE	SCORE
2	6919 (2)	8	40
4	7231 (1)	4	20
13	6966 (2)	7	35
14	6998 (2)	7	35
17	7284 (2)	3	15
18	7251 (2)	3	15
19	7292 (2)	3	15
20	6997 (2)	7	35
21	6765 (1)	10	50
25	7064 (2)	6	30
26	6937 (1)	7	35

TABLE 2.2

RANKING OF THE DISPLACEMENT ATTRIBUTE

EVALUATION SUMMARY

	2	4	13	14	17	18	19	20	21	25	26
COMBAT CAPABILITY	70	50	100	100	80	80	80	80	80	60	70
ACQUISITION COST	90	40	80	80	20	20	20	70	100	50	80
SHIP DISPLACEMENT	40	20	35	35	15	15	15	35	50	30	35
ENERGY CONSERVATION	35	20	30	30	15	30	25	50	45	50	35
MANNING REDUCTION	30	35	35	35	30	30	30	50	50	45	35
OPERABILITY	10	5	10	10	5	5	5	15	15	10	10
AVAILABILITY	15	10	15	15	10	10	10	15	15	10	15
RELIABILITY / MAINTAINABILITY	15	10	15	15	10	10	10	15	10	10	15
PASSIVE SURVIVABILITY	40	40	40	40	40	40	50	20	20	30	40
BLOCK UPGRADE / FUTURE GROWTH FLEXIBILITY	30	35	40	40	40	40	40	25	25	40	30
HABITABILITY	10	15	10	10	15	15	15	20	20	25	10
MINIMUM RISK	25	10	25	25	10	5	15	25	20	15	25
STANDARDIZATION	20	25	20	20	25	10	20	15	10	5	20
TOTAL	430	315	455	455	315	310	335	435	460	380	420

TABLE 2.3

EVALUATION SUMMARY OF CONCEPTS

CONCEPT COMPARISON

CONCEPT	COMBAT CAPABILITY	ACQUISITION COST	SHIP DISPLACEMENT	ENERGY CONSERVATION	MANNING	PASSIVE SURVIVABILITY
2 & 26 4-4000 DIESEL	GOOD	GOOD	GOOD	FAIR	FAIR	GOOD
13 & 14 4-2500 DIESEL	BEST	FAIR	GOOD	FAIR	FAIR	GOOD
21 3-3000 DIESEL	GOOD	BEST	BEST	GOOD	BEST	FAIR
4 4-2000 GAS TURBINE	FAIR	POOR	POOR	POOR	FAIR	GOOD
17, 18 & 19 4-2500 GAS TURBINE	GOOD	POOR	POOR	POOR	FAIR	GOOD
25 3-3000 GAS TURBINE	FAIR	POOR	FAIR	GOOD	GOOD	FAIR

TABLE 2.4

SUMMARY OF CONCEPT COMPARISION

fair, good, or best for each attribute as shown in Table 2.4.

A primary characteristic of this type of utility function is that it requires a through understanding of the decision makers priorities. Also, by changing the weighting factors to accommodate each decision maker, the results of the utility function can also change. Both issues could have a major impact on the decision. For example, concept 2 could have a displacement of 6919 5 Mtons while concept 13 could have a displacement of 6966 50 Mtons. Given this additional information, does the decision makers priorities remain the same ? If not, then how does the final evaluation change ? Also, the outcome of this evaluation can be completely changed if a second decision maker uses a different set of weighting factors.

The above issues of the utility function are currently being resolved. A sophisticated Analytic Hierarchy Process [2] has been developed and is being applied to concept formulation designs and feasibility studies. This process currently relies heavily on scoring values assigned based on individual experience. However, as more data becomes available the scoring values will reflect more the documented history and less the individual experience of designers.

A second characteristic of the current methodology is a heavy reliance on past designs. A great deal of useful information has been compiled based on past successful designs. Many of the estimating relationships and algorithms used in modern computerized synthesis models are based on

this information. A problem can arise from making low level tradeoffs based on this data. For example, if the weight of the propulsion plant per shaft horsepower is compared for a diesel plant and a gas turbine plant, the obvious choice, based on this information only, would be the gas turbine plant. However, synergistic effects that can result from combining two or more systems might be missed. For example, simply because system 1a is lighter then system 2a and system 1b is lighter then system 2b does not necessarily mean that the combination of systems 1a and 1b will be lighter than the combination of systems 2a and 2b. There can be hidden benefits in the integration of systems 2a and 2b which are not apparent until the systems are combined. This concept is especially true when comparing new technologies [3].

The solution is to evaluate as many possible combinations of systems and subsystems when exploring new concepts or technologies. The tedious task of balancing ship designs has been eliminated through the use of synthesis models and computers. The designer can now explore as many different concepts and combinations as desired. The only problem is being able to compile and analyze the output in an efficient and timely manner.

Multiple Attribute Tradeoff Analysis is a computerized decision methodology which can be useful in ship design. The methodology can handle a large number of concepts and treat the uncertainty factor in ship design. It does not require the development of large sophisticated models, but instead,

can use the output of many different small models. The Multiple Attribute Tradeoff Analysis (1) was developed at the Massachusetts Institute of Technology for use in the design of large electrical power generation and transmission systems. The methodology has been successfully applied in this application [4], [5].

(1) A current research project directed by Dr. H. M. Merrill of Power Technologies Inc. of Schenectady, New York and funded by Electric Power Research Institute Inc. of Palo Alto, California.

CHAPTER 3

MULTIPLE ATTRIBUTE TRADEOFF ANALYSIS

3.1 INTRODUCTION

Multiple attribute tradeoff analysis is an approach used to aid the decision maker in selecting the best design available in a system with multiple and/or conflicting attributes. The process involves a series of steps which allows the decision maker to eliminate redundant attributes and noncritical uncertainties as well as identify dominant and inferior options. It does not provide the decision maker with a scalar utility function representing the "goodness" of a particular design. However, the process does provide a set of graphs, tables, etc. which shows the relative "goodness" of the attributes of a reduced set of designs which pass initial screening criteria established by the analyst. The result is that the decision maker is presented with a reduced number of designs that have had the noncritical uncertainties and redundant attributes screened out. Therefore, the decision maker can concentrate on the real issues and see the relative "goodness" of the pertinent attributes of all the designs with merit.

3.2 BACKGROUND

In multiple attribute tradeoff analysis there are three classes of variables [6]:

OPTIONS AND PLANS - In ship design, options represent choices over which the designer has control and can vary.

These choices may include the type of propulsion or electric plant to be considered. A sample list of options is shown in Table 3.1. The list is not a comprehensive list and is used for illustrative purposes only.

TABLE 3.1

SAMPLE LIST OF OPTIONS

1-TYPE OF PROPULSION
- a) steam
  1. 600 lbs
  2. 1200 lbs
  3. pressure fired
- b) gas turbine
  1. 1st generation
  2. 2nd generation
- c) diesel
  1. low speed
  2. med speed
  3. high speed

2-NUMBER OF SHAFTS
- a) 1
- b) 2

3-RATING OF PRIME MOVERS

4-GENERATOR PRIME MOVERS
- a) steam
- b) gas turbine
- c) diesel

5-TYPE OF ELECTRIC POWER
- a) DC
- b) AC
  1. voltage level
  2. frequency
     - a. 60 Hz
     - b. 400 Hz
     - c. 800 Hz

6-TYPE OF DRIVE
- a) electric drive
- b) direct drive
- c) reduction gears
  1. reversing
  2. non-reversing

7-TYPE OF PROPELLER
- a) fixed pitch
- b) controllable pitch

8-NUMBER OF PRIME MOVERS
- a) 2
- b) 3
- c) 4

9-TYPE OF GENERATOR
- a) propulsion
- b) ship service
- c) combination of a+b

10-TYPE OF TRANSMISSION
- a) rating of cables
- b) rating of breakers
- c) transformers
- d) solid state
- c) 400Hz motor generator

A plan corresponds to a particular set of options denoted by a vector U. For example

$$U(i) = (1, 2, 3, 4, 5, 6, 7, 8, 9, 10)$$

where 1 through 10 are the options selected from Table 3.1 and U(i) is the ith plan being considered.

UNCERTAINTIES - Uncertainties provide a measure of events which have an effect on the attributes but are beyond the control of the designer. In ship design, uncertainties may include the fuel price or escalation rate. A sample list, not intended to be comprehensive, of uncertainties in ship design is given in Table 3.2. The vector Wk defined as

$$W(k) = (1, 2, 3)$$

denotes a particular set of values for the uncertainties.

TABLE 3.2

SAMPLE LIST OF UNCERTAINTIES

1-MODELS
- a) acquisition cost
- b) life cycle cost
- c) research and development cost

2-RISK
- a) technical
- b) schedule
- c) cost
  1. fuel
  2. discount rate
- d) research & development

3-EFFECTIVENESS
- a) our weapons
- b) enemy weapons
- c) battle scenario
- d) importance of attributes
  1. speed
  2. range
  3. payload

ATTRIBUTES - Attributes provide a measure of the effectiveness or goodness of a design. There are many, often conflicting, attributes in ship design. A possible list of attributes is given in Table 3.3.

TABLE 3.3

SAMPLE LIST OF ATTRIBUTES

1 - COST
- a) research and development cost
- b) operation and support cost
- c) lead ship cost
- d) follow on ship cost
- e) life cycle cost

2 - FULL LOAD DISPLACEMENT

3 - COMBAT CAPABILITY
- a) antiair warfare
- b) antisubmarine warfare
- c) antisurface warfare
- d) command and control

4 - SURVIVABILITY
- a) signatures
  1. acoustic
  2. infared
  3. radar cross-section
- b) protection
  1. fragment
  2. shock
  3. blast
  4. nuclear biological and chemical

5 - SPEED
- a) maximun sustained
- b) endurance

6 - ENDURANCE
- a) range
- b) period

7 - OPERABILITY
- a) maintainability
- b) reliability
- c) availability

The attribute vector is defined as:

$$A(i,k) = A(Ui/Wk)$$

The value of the vector of attributes is the result of a design of the ith plan, Ui, with a given set of values for the uncertainties, Wk. Attributes are assumed to be defined such that they are always positive and that smaller values are more desirable than larger values. For example if an increase in maximum speed is desirable then 1/Vs or 40 - Vs should be the attribute evaluated.

As an example case, consider a ship design with three different propulsion plants, steam, gas turbine, and diesel and an uncertainty that can have a value of low or high. For this case there are two attributes of concern, production cost and full load displacement. The definition of the option, uncertainty and attribute vectors for this case are shown below.

Ui= type of propulsion	Wk= value of risk
U1= steam	W1= low
U2= gas turbine	W2= high
U3= diesel	

A(i/k)= (production cost, displacement)

A(1/1)= ($ 367M, 4500 tons)

A(2/1)= ($ 370M, 4400 tons)

A(3/1)= ($ 375M, 4600 tons)

A(1/2)= ($ 357M, 4465 tons)

A(2/2)= ($ 365M, 4400 tons)

A(3/2)= ($ 373M, 4600 tons)

3.3 DEFINITIONS

Before the various steps of the multiple attribute tradeoff analysis are examined, definitions of difference vector, dominance and equivalence will be made [ ].

DIFFERENCE VECTOR:

Define

$$D(i,j/k) = A(i/k) - A(j/k)$$

to be the difference between the attribute vectors for two different plans i and j evaluated for the same value of the uncertainty vector k. Table 3.4 contains a list of the difference vectors for the example case.

TABLE 3.4

DIFFERENCE VECTORS

D(1,2/1) = A(1/1) - A(2/1) = ($ -3M, 100tons)

D(1,3/1) = A(1/1) - A(3/1) = ($ -8M, -100tons)

D(2,1/1) = A(2/1) - A(1/1) = ($ 3M, -100tons)

D(2,3/1) = A(2/1) - A(3/1) = ($ -5M, -200tons)

D(3,1/1) = A(3/1) - A(1/1) = ($ 8M, 100tons)

D(3,2/1) = A(3/1) - A(2/1) = ($ 5M, 200tons)

D(1,2/2) = A(1/2) - A(2/2) = ($ -8M, 65tons)

D(1,3/2) = A(1/2) - A(3/2) = ($ -16M,-135tons)

D(2,1/2) = A(2/2) - A(1/2) = ($ 8M, -65tons)

D(2,3/2) = A(2/2) - A(3/2) = ($ -8M, -200tons)

D(3,1/2) = A(3/2) - A(1/2) = ($ 16M, 135tons)

D(3,2/2) = A(3/2) - A(2/2) = ($ 8M, 200tons)

Since it is assumed that attributes are always positive and smaller values are more desirable then larger values, designs should be chosen which minimize the components of the attribute vector A. Therefore, it is reasonable to say that plan j dominates (i.e., is better than) plan i if D(i,j/k) is large in some sense. This concept of dominance is made more precise by the following definitions.

DOMINANCE:

CONDITIONAL STRICT DOMINANCE: Plan j strictly dominates plan i, conditional on k, if all components of

$$D(i,j/k) = A(i/k) - A(j/k)$$

are greater than zero. Consider the previous case of the propulsion plants.

$$D(3,2/1) = A(3/1) - A(2/1) = (\$\ 5M,\ 200\ tons)$$

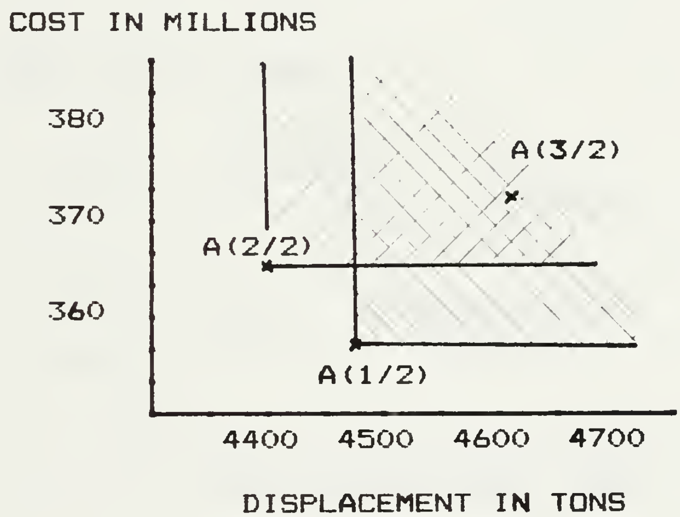
Since all components of D(3,2/1) are greater than zero, plan A(2/1) strictly dominates plan A(3/1), conditional on the value of k. Conditional strict dominance is illustrated in Figure 3.1.

CONDITIONAL SIGNIFICANT DOMINANCE: Plan j significantly dominates plan i, conditional on k, if at least one component of D(i,j/k) is "much worse" than zero and no component of D(i,j/k) is significantly better than zero. The analyst is required to assign values of "much worse" than zero and "not significantly better" than zero for each attribute. Table 3.5 gives some possible values of "much

TABLE 3.5

POSSIBLE VALUES FURNISHED BY ANALYST

	Production Cost	Full Load Displacement
Much Worse	$ 10M	75 tons
Not Significantly Better	$ -5M	-25 tons



- design A(2/2) dominates design A(3/2)

- design A(1/2) dominates design A(3/2)

- neither design A(2/2) or A(1/2) dominates the other

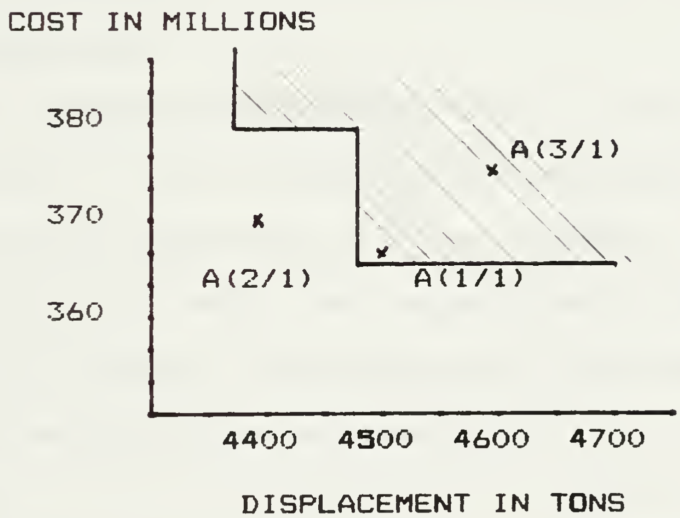
FIGURE 3.1

ILLUSTRATION OF CONDITIONAL STRICT DOMINANCE

worse" and "not significantly better" for the previous example case of propulsion plants. Consider the difference vector

$$D(1,2/1) = A(1/1) - A(2/1) = (\$ -3M,\ 100 \text{ tons})$$

Then D(1,2/1) would indicate that plan 2 significantly dominates plan 1, conditional on k, because displacement is much worse and cost is not significantly better. Conditional significant dominance is illustrated in Figure 3.2.



- design A(2/1) dominates design A(3/1)
- design A(2/1) dominates design A(1/1)

FIGURE 3.2

ILLUSTRATION OF CONDITIONAL SIGNIFICANT DOMINANCE

STRICT DOMINANCE: Plan j strictly dominates plan i if conditional strict dominance holds for all k. From Table 3.4 D(3,2/1) = ($ 5M, 200tons) and D(3,2/2) = ($ 8M, 200tons) would indicate plan 2 strictly dominates plan 3.

SIGNIFICANT DOMINANCE: Plan j significantly dominates plan i if conditional significant dominance holds for all k. From Table 3.4,

D(1,2/1) = ($ -3M, 100 tons) and D(1,2/2) = ($ -8M, 65 tons) would indicate plan 2 does NOT significantly dominate plan 1.

If probability distributions for the uncertainties Wk have been hypothesized, a somewhat different type of dominance can be defined:

STRICT DOMINANCE WITH PROBABILITY P: Plan j strictly dominates plan i with probability P if the probability of conditional strict dominance is P or greater. A similar definition can be made for significant dominance with probability P. However, for subsequent development such a probabilistic structure is not assumed.

EQUIVALENCE:

If all the components of D(i,j/k) are sufficiently small in magnitude, it is reasonable to say that plans i and j are equivalent.

The definition of significant dominance required the specification, for each attribute, of two values which determined whether a difference is

- "much worse"
- "not significantly better"

These two numbers, per attribute, lead to more precise definitions for the concept of equivalence.

CONDITIONAL LOOSE EQUIVALENCE: Plans i and j are loosely equivalent, conditional on k, if the magnitude of all the components of D(i,j/k) are less than the values that determine "much worse". For example, consider the difference vector D(1,2/2) = ($ -8M, 65 tons). The values of the difference vector are less than the values for "much worse" given in Table 3.5. Therefore, designs 1 and 2, conditional on k = 2, are loosely equivalent.

CONDITIONAL TIGHT EQUIVALENCE: Plans i and j are tightly equivalent, conditional on k, if the magnitude of all components of D(i,j/k) are less than the magnitude of the values that determine "not significantly better". Consider the difference vector D(1,2/1) = ($ -3M, 100 tons) as an example. The value of the production cost is less than the value of " not significantly better" given in Table 3.5, but the value of displacement in the difference vector is not less than the value listed in Table 3.5. Therefore, designs 1 and 2 are NOT tightly equivalent, conditional on k = 1.

LOOSE EQUIVALENCE: Plans i and j are loosely equivalent if conditional loose equivalence holds for all values of k.

TIGHT EQUIVALENCE: Plans i and j are tightly equivalent if conditional tight equivalence holds for all values k.

Three important points must be made concerning equivalence:

1. If plans i and j are tightly equivalent then they are also loosely equivalent but not vice versa.

2. The fact that plans 1 and 2 are equivalent (either tight or loose) and plans 2 and 3 are equivalent does not necessarily imply that plans 1 and 3 are equivalent.

3. The condition that plans 1 and 2 are equivalent does not mean they are "physically close or similar". They might involve many different particular options. They are equivalent only in the sense that they produce "similar" values for the attributes.

3.4 PROCESS OF ANALYSIS

Given the above definitions the various steps of the multiple attribute tradeoff analysis can be examined. There are six basic steps to the process each with a specific purpose as defined below and summarized in Figure 3.3 [ ].

STEP I - DECISION SET

The decision set is defined to be the set of all plans j which are not dominated by any other plan. Three different ways to define a decision set are

- TRADEOFF CURVE SET: Set of all plans j that are not strictly dominated by any other plan
- KNEE SET: Set of all plans that are not significantly dominated by any other plan
- KNEE OF THE TRADEOFF CURVE SET: Set of all plans j that belong to both the tradeoff curve set and the knee set

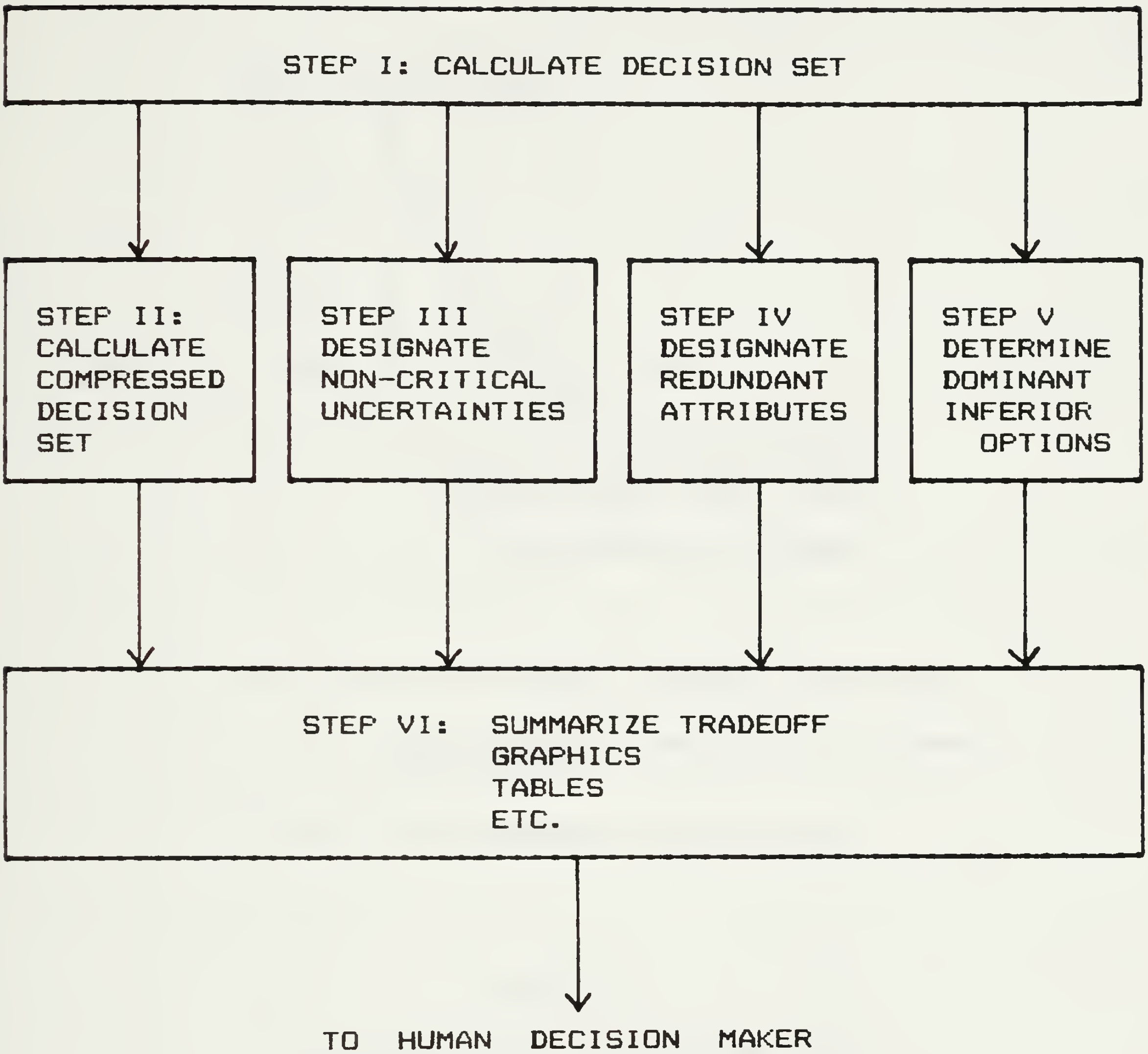
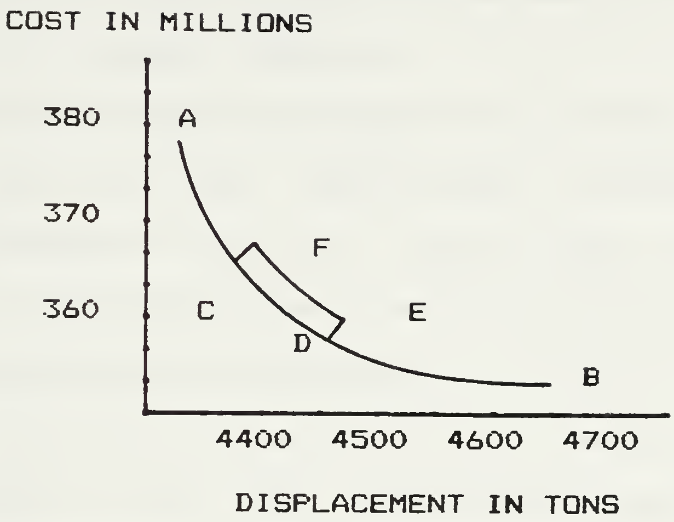


FIGURE 3.3

SIX STEPS OF MULTIPLE ATTRIBUTE TRADEOFF ANALYSIS

Figure 3.4 compares these three sets. For the purpose of illustration, only the axis of conditional strict



- A to B defines the Tradeoff Curve Set
- C to D defines the Knee of the Tradeoff Curve Set
- C D E to F defines the Knee Set

FIGURE 3.4

ILLUSTRATION OF DECISION SETS

dominance, with k = 2 is shown. The motivation for the choice of names for these three sets of designs can be seen in Figure 3.4.

The tradeoff curve set shown in Figure 3.4 forms the boundary between the set of possible and unachievable attributes. Often a continuous line is drawn through the

attributes to yield a curve, hence the name tradeoff curve. This curve is also known by other names such as the Pareto Frontier or the tradeoff frontier.

The knee set shown in Figure 3.4 is formed by all of the plans that are not significantly dominated by other plans. This approach allows for plans which are strictly dominated, but not significantly worse, to also be considered as possible solutions to the design.

The knee of the tradeoff curve set shown in Figure 3.4 is the tradeoff curve set with the extreme limbs removed under the belief that the plans corresponding to such limbs are undesirable. For example, the upper limb plans result in a significant increase in one attribute without a significant decrease in the other.

STEP II - COMPRESSED DECISION SET

If two plans in the decision set have corresponding attribute vectors that are close, then they are equivalent and can be grouped together. This grouping yields a compressed decision set which has fewer number of "separate elements" than the decision set itself. More precisly:

COMPRESSED DECISION SET: A decision set where all equivalent (tight or loose) plans are grouped together.

STEP III - NONCRITICAL UNCERTAINTIES

The introduction of uncertainty can never reduce the

number of plans in a decision set. Examination of a simple case will help clarify this statement. The decision set is comprised of plans which are neither strictly nor significantly dominated. Therefore, conditional strict or significant dominance does not hold for at least one value of k. Increasing the number of values of k, introducing uncertainties, will not cause plans which were not previously dominated for at least one value of k to now be dominated. As a result, the decision set can not be reduced. On the other hand, if the number of uncertainties is changed and the decision set is not significantly changed, then the uncertainties that were added or removed are not critical. A more precise definition is

NONCRITICAL UNCERTAINITY: A component of the uncertainity vector W is noncritical if its removal from W causes only an insignificant reduction in the decision set or causes no change in the compressed decision set.

Note that a noncritical component of the uncertainity vector is defined by its effect on the decision set, not by its effect on the attributes. A noncritical uncertainity can have a major impact on the attributes.

STEP IV - DESIGNATE REDUNDANT ATTRIBUTES

For the same reasons that an increase in the uncertainty components cannot cause the decision set to be reduced, an increase in the number of attributes cannot cause

the decision set to be reduced. Likewise, if the number of attributes is changed and the decision set is not significantly changed, then there are redundant attributes. A more precise definition is

REDUNDANT ATTRIBUTES: A component of the attribute vector A is redundant if its removal from or addition to A causes only an insignificant change in the decision set or causes no change in the compressed decision set.

Note that redundant attributes are not necessarily unique. For example, if one of two attributes is redundant, either one but not both can be removed.

STEP V - DETERMINE DOMINANT AND INFERIOR OPTIONS

Each plan i is composed of a combination of options. Certain options may be dominant or inferior for all of the plans in the decision set. Precise definitions are

DOMINANT OPTIONS: A dominant option appears in all plans in the decision set.

INFERIOR OPTIONS: An inferior option appears in no plans in the decision set.

STEP VI - SUMMARIZE TRADEOFF

The first five steps of the multiple attribute tradeoff analysis are designed to be done by a digital computer. Given the A(i/k) i = 1,2,3,... vectors, the only other input required is the specification of the "significant

levels" (two per attribute) associated with the significant dominance test. The result of the first five steps is:

- a compressed decision set of plans to be considered
- designation of noncritical uncertainties, redundant attributes, and dominant and inferior options

This information enables the analyst to concentrate on the real issues.

Step VI is not an automatic computer process. Step VI is to summarize the key tradeoffs, etc. in a clear, concise and understandable format for use by the human decision maker. This step requires a lot of thought and is very application specific.

In the process of step VI, the analyst may choose to vary the values of the significant levels used to specify dominance. Additionally, the analyst might choose to introduce probability distributions on the critical uncertainties. Decision theory based on expected values of utility function could also be introduced if a single "optimum" plan is desired. Such procedures will be much more effective after the first five steps have been completed because all of the noncritical issues have been "screened out".

CHAPTER 4

CASE STUDY

4.1 INTRODUCTION

This case study was conducted to demonstrate and validate the use of Multiple Attribute Tradeoff Analysis in ship design. In order to keep the case study simple, uncertainty will not be considered. A synthesis model was used to generate all the attributes for the case study. However, the attributes used by the Multiple Attribute Tradeoff Analysis can be generated by any consistent source. The steps used to carry out the case study are outlined below.

(1) select a synthesis model to evaluate each design

(2) select the options to be varied to generate the designs to be examined

(3) select the attributes to be used as a measure of "goodness" for each design

(4) synthesize each design to generate its attributes for evaluation

(5) apply the Multiple Attribute Tradeoff Analysis to the results of the synthesis phase to determine:

a) the decision sets
   1. not strictly dominated
   2. not significantly dominated

b) the compressed decision set
   1. not strictly dominated
   2. not significantly dominated

c) redundant attributes

d) inferior and dominant options

e) summarize tradeoff using graphics and tables

4.2 SYNTHESIS MODEL

A synthesis model was used for the case study because a large number of ship designs could be evaluated in a short period of time. There are a wide variety of synthesis models available with varying degrees of complexity, accuracy, and interaction with the designer. For the case study the "Ship Synthesis Model For Naval Surface Ships", reference [7], developed by Michael Robert Reed, also known as the Reed Model, was used for the following reasons:

(1) it can be run on a personal computer

(2) it can handle a batch mode input for synthesizing a large number of ship designs

(3) it can be easily modified to output the selected attributes in a useful format

(4) it has a variety of user controlled inputs for varying selected options to generate different designs

(5) it is readily available at MIT and is used in several of the ship design courses in the Naval Construction and Engineering Curriculum

(6) the estimating algorithms produce consistent results and all designs are handled in a consistent manner

Many of the synthesis models available would provide more accurate results. However, none of these models met all the requirements listed above. For example, ASSET cannot handle a batch mode input and the cost models used by the

Navy are not readily available for public use. Also, the case study is not so much concerned with the accuracy of the synthesis model, but with the application of a decision theory methodology to the results of the synthesis model.

4.3 SELECTION OF OPTIONS

The criteria for the selection of options were:

(1) the options need to be able to produce a large number of alternative designs

(2) the options needed to be available on the Reed Model

Based on these criteria, it was decided the case study would reflect a low level tradeoff analysis of propulsion and electrical plant combinations. The following options are available on the Reed Model and were used in the case study.

A) Type of Propulsion Plant
   1. 600 lb steam
   2. 1200 lb steam
   3. 1200 lb pressure fired steam
   4. 1st generation gas turbines
   5. 2nd generation gas turbines
   6. Diesel engines
      a. low speed
      b. medium speed
      c. high speed

B) Number of Boilers
   1. 1, 2, or 3 with one shaft
   2. 2, 3, or 4 with two shafts

C) Number of Engines
   1. 1 or 2 with steam plants
   2. 1, 2, 3, or 4 with gas turbine and diesel plants

D) Number of Shafts (1 or 2)

E) Type of Propeller
   1. fixed pitch
   2. controllable pitch

F) Ship Service Electrical Generators
1. steam in conjunction with a steam plant
2. 1st generation gas turbine
3. 2nd generation gas turbine
4. low speed diesel
5. medium speed diesel
6. high speed diesel

G) Emergency Electrical Generators (steam plants only)
1. 1st generation gas turbine
2. 2nd generation gas turbine
3. low speed diesel
4. medium speed diesel
5. high speed diesel

H) Number of Ship Service Generators (3 or 4)

The selection of the above options results in an option vector of the following form

$$Ui = (A, B, C, D, E, F, G, H)$$

where Ui represents the ith design to be synthesized. A list of the options of all the designs synthesized is given in Appendix I with a corresponding ship number.

4.4 SELECTION OF ATTRIBUTES

A set of attributes to represent the relative "goodness" of each design was selected in phase three. To demonstrate the flexibility of the Multiple Attribute Tradeoff Analysis, the following mixture of attributes was selected:

- one whole ship performance attribute
- three size and cost attributes
- three machinery plant attributes

A balanced selection of attributes allows each design to be evaluated by its impact on ship performance, size and cost characteristics, and machinery plant characteristics.

Maximum sustained speed was selected as the performance attribute. Full load displacement, total internal volume, and follow on ship acquisition cost were selected as the three size and cost attributes. Propulsion machinery plant weight (W200) per shaft horsepower (SHP), electrical machinery plant weight (W300) per installed kilowatts (KW), and the sum of weight group W200 + W300 were selected as the three plant attributes.

The selection of attributes provides for an attribute vector of the following form

A(i) = (Vs, DISP, VOL, W200/SHP, W300/KW,

W200 + W300, COST)

where A(i) represents the attributes of the ith design. A list of all the attributes is given by ship number in Appendix II. All of the attributes with the exception of cost were obtained from the Reed Model. Cost was calculated by summing the primary weight groups multipled by a cost estimating ratio.

It is important to realize that these attributes do not have to come from the same synthesis model. For example, if acquisition and life cycle cost were selected as attributes, then values representing them could come from a cost model which was completely separate from the ship synthesis model. The only requirement is that the attribute be available for each design being considered. Therefore, large complex synthesis models are not a requirement for the Multiple Attribute Tradeoff Analysis to be effective.

4.5 SYNTHESIS OF EACH DESIGN

As indicated earlier, the REED MODEL was used to synthesize each plan into a balanced design. In order to keep the variations in the attributes of each design a reflection of different plant options, all other inputs were held constant. For example, the payload, crew size, type of heating, accommodations, material, margins, endurance range, and endurance speed were all held constant. Therefore, the secondary and tertiary changes in the hull structure, internal volume, etc. are due to the changes in the machinery plant. In order to force the model to produce similar ships, the shaft horse power was fixed at 40,000 SHP while the speed was allowed to vary. Similarly, the length of the ship was fixed at 400 ft while the beam and draft were allowed to vary to accommodate the different machinery plants. Holding the length constant, while varying the machinery plant, may not result in the most balanced design. But, for the purpose of illustrating the procedure it is satisfactory.

All the designs consisting of the various options were then synthesized using the Reed Model. The options are given in Appendix I and the attributes are given in Appendix II. The ship number given in column 1 for both appendices relates a given set of attributes to a given set of options. Examination of the attributes in Appendix II reveals that the Reed Model could not synthesize a balanced design for cases 600-609 and 650-669. In these cases the designs could not pass the stability check. Again, it should be pointed out

that the Reed Model is not the most sophisticated model available, but that should not detract from the illustration. Since the model did not provide attributes for these cases, their sets of options were not considered by the Multiple Attribute Tradeoff Analysis.

4.6 RESULTS OF THE MULTIPLE ATTRIBUTE TRADEOFF ANALYSIS

The first five steps of the tradeoff analysis are designed to be carried out on a digital computer. These steps include the determination of the decision set, compressed decision set, noncritical uncertainties, redundant attributes, and dominant and inferior options. A Fortran program was written to carry out the first five steps of the analysis which was described in Chapter 3. A copy of the program is given in Appendix III.

The case study analysized the data in three separate passes. The first pass analysized all the designs listed in Appendices I and II with the exceptions already noted. The second and third passes analysized only the options with gas turbine and steam propulsion plants respectively. In this way not only could all the options be analysized together but also by type of propulsion plant.

In making the first pass and all subsequent passes the values of "much worse" and "not significantly better" were determined in the following manner. The difference between the maximum and minimum values for each attribute was determined for each pass. Then 10% of the difference was

used for the value of "much worse" and 1% of the difference was used for the value of "not significantly better". The values of "much worse" and "not significantly better" are listed for each pass in Table 4.1.

TABLE 4.1

VALUES OF MUCH WORSE AND NOT SIGNIFICANTLY BETTER

ALL DATA	SPD	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
much worse	.30	166.	9583.	4.1	7.8	87.8	28.8
not significantly better	.03	16.6	958.3	.41	.78	8.78	2.88
GAS TURBINE DATA	**SPD**	**DISP**	**INTVOL**	**W200 /SHP**	**W300 /KW**	**W200+ W300**	**COST**
much worse	.10	93.1	2525.	.71	6.9	18.8	7.8
not significantly better	.01	9.31	252.5	.07	.69	1.88	.78
STEAM DATA	**SPD**	**DISP**	**INTVOL**	**W200 /SHP**	**W300 /KW**	**W200+ W300**	**COST**
much worse	.10	63.7	2210.	.92	7.0	28.8	9.4
not significantly better	.01	6.4	221.0	.01	.70	2.90	.94

The results of the first five steps of the Multiple Attribute Tradeoff Analysis, done by digital computer, is given in tabular form. The output of pass one through pass three is given in Tables 4.2 through 4.4 respectively. A quick examination of Tables 4.2 and 4.3 shows the results of

pass one and two are identical. In both cases the options of the designs not strictly or significantly dominated are all dominant options. The propulsion plants of these cases are 2nd generation gas turbine plants. Therefore, it only makes sense, when running just the gas turbine plants, that the same options would again dominate and give the same results. Because the results of pass one and two are identical, a detailed analysis will be made on only pass one. However, the analysis of pass one equally applies to pass two.

In the case study there are seven attributes to be considered as discussed in section 4.4. To help illustrate the analysis all the attributes have been plotted verses displacement. These graphs are:

Figure 4.1 Displacement vs 1000 / Vs
Figure 4.2 Displacement vs Internal Volume
Figure 4.3 Displacement vs W200 / SHP
Figure 4.4 Displacement vs W300 / KW
Figure 4.5 Displacement vs W200 + W300
Figure 4.6 Displacement vs Cost

The examination of the graphs reveals, for the most part, a clean breakout of the designs by propulsion plant type. There is some overlap in Figures 4.1 and 4.4. Given that a smaller value of an attribute is considered to be better than a larger value, it is obvious that the gas turbine plants should comprise most of the decision set. It should be noted that the breakout only applies for propulsion plants in the 40,000 SHP range and the given design limitations of the case study. It is also fairly easy to examine each graph individually and identify one or two

[illegible]

TABLE 4.2

RESULTS OF THE MULTIPLE ATTRIBUTE TRADEOFF ANALYSIS

ALL PROPULSION PLANTS

DESIGNS NOT STRICTLY DOMINATED

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
618.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.39	3390.45	429614.40	15.17	66.05	377.09	268.69
619.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.48	3409.53	431875.30	15.22	63.70	385.49	272.23

DESIGNS NOT SIGNIFICANTLY DOMINATED

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
618.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.39	3390.45	429614.40	15.17	66.05	377.09	268.69
619.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.48	3409.53	431875.30	15.22	63.70	385.49	272.23

COMPRESSED DECISION SET (NOT STRICTLY DOMINATED)

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
618.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.39	3390.45	429614.40	15.17	66.05	377.09	268.69
619.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.48	3409.53	431875.30	15.22	63.70	385.49	272.23

COMPRESSED DECISION SET (NOT SIGNIFICANTLY DOMINATED)

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
618.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.39	3390.45	429614.40	15.17	66.05	377.09	268.69
619.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.48	3409.53	431875.30	15.22	63.70	385.49	272.23

IN COLUMN 8 OPTION .0 IS DOMINANT
IN COLUMN 7 OPTION 6.0 IS DOMINANT
IN COLUMN 6 OPTION 2.0 IS DOMINANT
IN COLUMN 5 OPTION 1.0 IS DOMINANT
IN COLUMN 4 OPTION 2.0 IS DOMINANT
IN COLUMN 3 OPTION .0 IS DOMINANT
IN COLUMN 2 OPTION 5.0 IS DOMINANT

COLUMN 15 IS REDUNDANT
COLUMN 14 IS REDUNDANT
COLUMN 12 IS REDUNDANT
COLUMN 11 IS REDUNDANT
COLUMN 10 IS REDUNDANT
COLUMN 9 IS REDUNDANT

TABLE 4.3

RESULTS OF THE MULTIPLE ATTRIBUTE TRADEOFF ANALYSIS

GAS TURBINE PROPULSION PLANTS

DESIGNS NOT STRICTLY DOMINATED

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
618.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.39	3390.45	429614.40	15.17	66.05	377.09	268.69
619.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.48	3409.53	431875.30	15.22	63.70	385.49	272.23

DESIGNS NOT SIGNIFICANTLY DOMINATED

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
618.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.39	3390.45	429614.40	15.17	66.05	377.09	268.69
619.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.48	3409.53	431875.30	15.22	63.70	385.49	272.23

COMPRESSED DECISION SET (NOT STRICTLY DOMINATED)

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
618.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.39	3390.45	429614.40	15.17	66.05	377.09	268.69
619.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.48	3409.53	431875.30	15.22	63.70	385.49	272.23

COMPRESSED DECISION SET (NOT SIGNIFICANTLY DOMINATED)

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
618.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.39	3390.45	429614.40	15.17	66.05	377.09	268.69
619.00	5.00	.00	2.00	1.00	2.00	6.00	.00	33.48	3409.53	431875.30	15.22	63.70	385.49	272.23

IN COLUMN 8 OPTION .0 IS DOMINANT
IN COLUMN 7 OPTION 6.0 IS DOMINANT
IN COLUMN 6 OPTION 2.0 IS DOMINANT
IN COLUMN 5 OPTION 1.0 IS DOMINANT
IN COLUMN 4 OPTION 2.0 IS DOMINANT
IN COLUMN 3 OPTION .0 IS DOMINANT
IN COLUMN 2 OPTION 5.0 IS DOMINANT

COLUMN 15 IS REDUNDANT
COLUMN 14 IS REDUNDANT
COLUMN 12 IS REDUNDANT
COLUMN 11 IS REDUNDANT
COLUMN 10 IS REDUNDANT
COLUMN 9 IS REDUNDANT

TABLE 4.4

RESULTS OF MULTIPLE ATTRIBUTE TRADEOFF ANALYSIS

STEAM PROPULSION PLANTS

DESIGNS NOT STRICTLY DOMINATED

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
429.00	3.00	1.00	1.00	1.00	2.00	1.00	5.00	35.10	4015.70	483084.60	26.31	65.51	615.98	358.91
430.00	3.00	1.00	1.00	1.00	2.00	2.00	.00	34.29	3714.45	464137.40	26.27	79.31	596.58	345.08
432.00	3.00	1.00	1.00	1.00	2.00	3.00	.00	34.29	3714.45	464137.40	26.27	79.31	596.58	345.08
436.00	3.00	1.00	1.00	1.00	2.00	5.00	.00	34.40	3752.62	464596.10	26.27	93.11	618.79	353.61
438.00	3.00	1.00	1.00	1.00	2.00	6.00	.00	34.22	3689.11	463816.90	26.27	70.44	582.31	339.59
439.00	3.00	1.00	1.00	1.00	2.00	6.00	.00	34.28	3711.27	466730.90	26.28	67.73	590.20	343.16
469.00	3.00	2.00	1.00	1.00	2.00	1.00	5.00	35.08	4012.25	482973.50	26.31	65.50	615.97	358.67
470.00	3.00	2.00	1.00	1.00	2.00	2.00	.00	34.32	3712.38	464106.10	26.27	79.31	596.58	345.06
472.00	3.00	2.00	1.00	1.00	2.00	3.00	.00	34.32	3712.38	464106.10	26.27	79.31	596.58	345.06
476.00	3.00	2.00	1.00	1.00	2.00	5.00	.00	34.42	3750.82	464574.30	26.27	93.11	618.79	353.57
478.00	3.00	2.00	1.00	1.00	2.00	6.00	.00	34.26	3687.39	463799.10	26.27	70.44	582.31	339.59
479.00	3.00	2.00	1.00	1.00	2.00	6.00	.00	34.32	3709.17	466699.00	26.28	67.73	590.19	343.14

DESIGNS NOT SIGNIFICANTLY DOMINATED

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
429.00	3.00	1.00	1.00	1.00	2.00	1.00	5.00	35.10	4015.70	483084.60	26.31	65.51	615.98	358.91
438.00	3.00	1.00	1.00	1.00	2.00	6.00	.00	34.22	3689.11	463816.90	26.27	70.44	582.31	339.59
439.00	3.00	1.00	1.00	1.00	2.00	6.00	.00	34.28	3711.27	466730.90	26.28	67.73	590.20	343.16
469.00	3.00	2.00	1.00	1.00	2.00	1.00	5.00	35.08	4012.25	482973.50	26.31	65.50	615.97	358.67
478.00	3.00	2.00	1.00	1.00	2.00	6.00	.00	34.26	3687.39	463799.10	26.27	70.44	582.31	339.59
479.00	3.00	2.00	1.00	1.00	2.00	6.00	.00	34.32	3709.17	466699.00	26.28	67.73	590.19	343.14

COMPRESSED DECISION SET (NOT STRICTLY DOMINATED)

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
429.00	3.00	1.00	1.00	1.00	2.00	1.00	5.00	35.10	4015.70	483084.60	26.31	65.51	615.98	358.91
430.00	3.00	1.00	1.00	1.00	2.00	2.00	.00	34.29	3714.45	464137.40	26.27	79.31	596.58	345.08
436.00	3.00	1.00	1.00	1.00	2.00	5.00	.00	34.40	3752.62	464596.10	26.27	93.11	618.79	353.61
438.00	3.00	1.00	1.00	1.00	2.00	6.00	.00	34.22	3689.11	463816.90	26.27	70.44	582.31	339.59
439.00	3.00	1.00	1.00	1.00	2.00	6.00	.00	34.28	3711.27	466730.90	26.28	67.73	590.20	343.16

TABLE 4.4 (con't)

RESULTS OF MULTIPLE ATTRIBUTE TRADEOFF ANALYSIS

STEAM PROPULSION PLANTS

COMPRESSED DECISION SET (NOT SIGNIFICANTLY DOMINATED)

SHIP NUM	PROP TYPE	NB	NE	NS	PRP TYPE	SSE	EME	1000 /Vs	DISP	INTVOL	W200 /SHP	W300 /KW	W200+ W300	COST
429.00	3.00	1.00	1.00	1.00	2.00	1.00	5.00	35.10	4015.70	483084.60	26.31	65.51	615.98	358.91
438.00	3.00	1.00	1.00	1.00	2.00	6.00	.00	34.22	3689.11	463816.90	26.27	70.44	582.31	339.59
439.00	3.00	1.00	1.00	1.00	2.00	6.00	.00	34.28	3711.27	466730.90	26.28	67.73	590.20	343.16

```
IN COLUMN  8 OPTION 1.0 IS INFERIOR
             OPTION 2.0 IS INFERIOR
             OPTION 3.0 IS INFERIOR
             OPTION 4.0 IS INFERIOR
IN COLUMN  7 OPTION 4.0 IS INFERIOR
IN COLUMN  6 OPTION 2.0 IS DOMINANT
IN COLUMN  5 OPTION 1.0 IS DOMINANT
IN COLUMN  4 OPTION 1.0 IS DOMINANT
IN COLUMN  3 OPTION 3.0 IS INFERIOR
             OPTION 4.0 IS INFERIOR
IN COLUMN  2 OPTION 3.0 IS DOMINANT
```

COLUMN 15 IS REDUNDANT
COLUMN 14 IS REDUNDANT
COLUMN 11 IS REDUNDANT

designs which are better than the other designs. The better designs would be located in the lower left corner of the graph. However, what is not apparent from examining the individual plots is if the same design is dominating on all the graphs. That is, if design X is dominating on Figure 4.1 does not necessarily imply that design X is dominating on Figure 4.6. The Multiple Attribute Tradeoff Analysis simultaniously compares all the attributes of the designs and can readily answer this question for the decision maker.

The first step of the Multiple Attribute Tradeoff Analysis compares the attributes of each design to determine all designs which are not strictly dominated. This decision set forms the boundary between the possible and unachievable attributes. For the pass when all the data was analyzed Table 4.2 indicates that there are only two designs which are not strictly dominated by another design. The values of the attributes for the designs not strictly dominated give the lowest possible values that can be achieved in a balanced design. A closer look indicates to the decision maker that design number 618 incorporates the best possible value of six out of the seven attributes. Design number 619 has the best value of W300 / KW. The designs not strictly dominated are plotted in Figures 4.1b through 4.6b.

Table 4.2 also shows that based on the values selected for "much worse" and "not significantly better" there are only two designs which are not significantly dominated by another design. The strict and significant decision sets are

identical. As will be shown later this is not always the case. However, it would indicate to the decision maker that based on the values of "much worse" and "not significantly better" listed in Table 4.1 these two designs are so dominant that all other concepts do not merit consideration. Figures 4.1.c through 4.6.c are plots of the designs not significantly dominated.

In determining the compressed decision sets for the purpose of the case study the program only tested for loose equivalence and did not determine a compressed decision set based on tight equivalence. However, if two designs are loosely equivalent then they are also tightly equivalent. Table 4.2 shows that the compressed decision sets for both the strict and significant decision sets are equal. The compressed decision sets consist of design 618. This would indicate to the decision maker that the designs listed in the strict and significant decision sets basically yield the same values for the attributes and the advantage of one design over another is marginal. Therefore, if the concept behind one design is more appealing to the decision maker than another the impact of the choice on the attributes of the system are marginal. Again, the compressed decision sets are a function of the values selected for "much worse" and "not significantly better".

Table 4.2 list the following dominant and inferior options:

dominant options
- column 2 option 5 ==> 2nd generation gas turbine
- column 3 option 0 ==> no boilers
- column 4 option 2 ==> two gas turbines
- column 5 option 1 ==> single shaft
- column 6 option 2 ==> fixed pitch propeller
- column 7 option 6 ==> high speed diesel generators
- column 8 option 0 ==> no emergency generators

inferior options
- all other options not listed as dominant in the columns above (in this particular case all columns contained a dominant option)

As can be seen above the options of the designs selected as not strictly or significantly dominated are all dominant options. The only difference between the designs is in the number of high speed diesel generators; 3 or 4. This would indicate to the decision maker that based on the attributes selected for evaluation and the method used to determine them, the only options which merit further investigation are those listed above. The analysis indicates that both steam and diesel propulsion plants are inferior to gas turbines. Also, the analysis indicates that when coupled with a gas turbine propulsion plant a high speed diesel generator is the best alternative. That is, all other types of generators are inferior. Again, it should be emphasized that these results are purely a function of the options, attributes, and synthesis model used to generate the attributes. The case study is concerned with demonstrating a methodology and not with determining the best propulsion plant or generator for use by the Navy.

At the bottom of Table 4.2 a list of six redundant columns is given. These columns equate to the following attributes:

```
column 15 ==> COST
column 14 ==> W200 + W300
column 12 ==> W200 / SHP
column 11 ==> INTERNAL VOLUME
column 10 ==> DISPLACEMENT
column  9 ==> 1000 / Vs
```

As discussed in Chapter 3, six redundant attributes would indicate that any five of the six could be eliminated and not effect the results. For the decision maker this would indicate that only one of the above attributes needs to be coupled with column 13 to obtain the same decision sets. Therefore, if several new attributes were to be analyzed with the old attributes, column 13 and one of the above columns would yield the same result as including all the above columns in the analysis. By keeping the number of attributes at a minimum without losing any information, the issues at hand become clearer. The identification of redundant attributes tells the decision maker that the result of the decision will be the same even though a smaller number of attributes are being considered.

Pass three which compared just the steam propulsion plants will also be analyzed . In this case, there is a larger number of designs not strictly dominated as listed in Table 4.4. With the increased number of designs, the lowest possible values of the attributes is no longer readily apparent from Table 4.4. However, the graphs of the designs

not strictly dominated, given in Figures 4.1.b through 4.6.b, do make the lowest possible values apparent. The Figures also indicate that the lowest values are spread out between several designs and a design with the lowest value in one attribute can have a much higher value in a different attribute. For example, in Figure 4.2.b there are two designs which have a significantly higher displacement and internal volume than the rest of the designs. Because these two designs are not strictly dominated indicates that they have the lowest possible value for an attribute other than displacement or internal volume. The two designs have the lowest possible value for attribute W300 / KW. This indicates to the decision maker that the best of all the attributes cannot be incorporated into one design and a tradeoff will have to made. The tradeoff will be discussed further as the rest of the results are analyzed.

Table 4.4 also shows that all the designs in the not significantly dominated set are in the the not strictly dominated set. The lack of any different designs indicates that there are no designs with attribute values close to the attribute values of the strictly dominated set. As a result there is nothing else to be learned from the significantly dominated set. It needs to be pointed again that this is not always the case. There can be designs with attributes close to those in the knee of the tradeoff curve that are included in the significantly dominated decision set.

The compressed decision sets in Table 4.4 provide a

reduced number of designs to be evaluated. This allows the decision maker to get a crisper picture of the general values of the attributes of the designs not dominated. For example, it is much easier to evaluate the effect on the other attributes of selecting a design with the lowest possible value for the W300 / KW. From Table 4.4 it is apparent that the selection of the lowest possible value of W300 / KW would generally produce a significant increase in the other six attributes. However, there are other designs with lower values for the other six attributes that would not produce that large of an increase in W300 / KW.

Note that the compressed decision set is based on the values of the attributes and not the options. Therefore, the compressed decision set does not necessarily provide a sampling of all the options in the full decision sets. As a result a large amount of information is lost if only the compressed decision set is examined. The analyst needs to keep in mind that the compressed decision set only provides an indication of the range of values that can be achieved for the attributes and not a list of the optimum concepts.

Table 4.4 list the following dominant and inferior options:

```
dominant options
     column 2 option 3 ==> pressure fired boiler
     column 4 option 1 ==> one main engine
     column 5 option 1 ==> single shaft
     column 6 option 2 ==> fixed pitch propeller
```

inferior options

```
    column 3 option 3 ==> 3 main boilers
             option 4 ==> 4 main boilers
    column 7 option 4 ==> low speed diesel generators
    column 8 option 1 ==> 1st generation gas turbine
                          emergency generator
             option 2 ==> 2nd generation gas turbine
                          emergency generator
             option 3 ==> low speed diesel emergency
                          generator
             option 4 ==> medium speed diesel
                          emergency generator
```

In examining the dominant options it becomes apparent that the best steam concept is a pressure fired boiler with a single shaft and fixed pitch propeller. The inferior options in this case deal mainly with the electrical plant. The one exception is the number of boilers which indicates that 3 or 4 boilers is an inferior selection. The only type of ship service generator not recommended as a viable concept is low speed diesel generators. Column 8 lists all emergency generators but high speed diesel as inferior. The reason a high speed diesel emergency generator is not a dominant option is because certain concepts do not require an emergency generator.

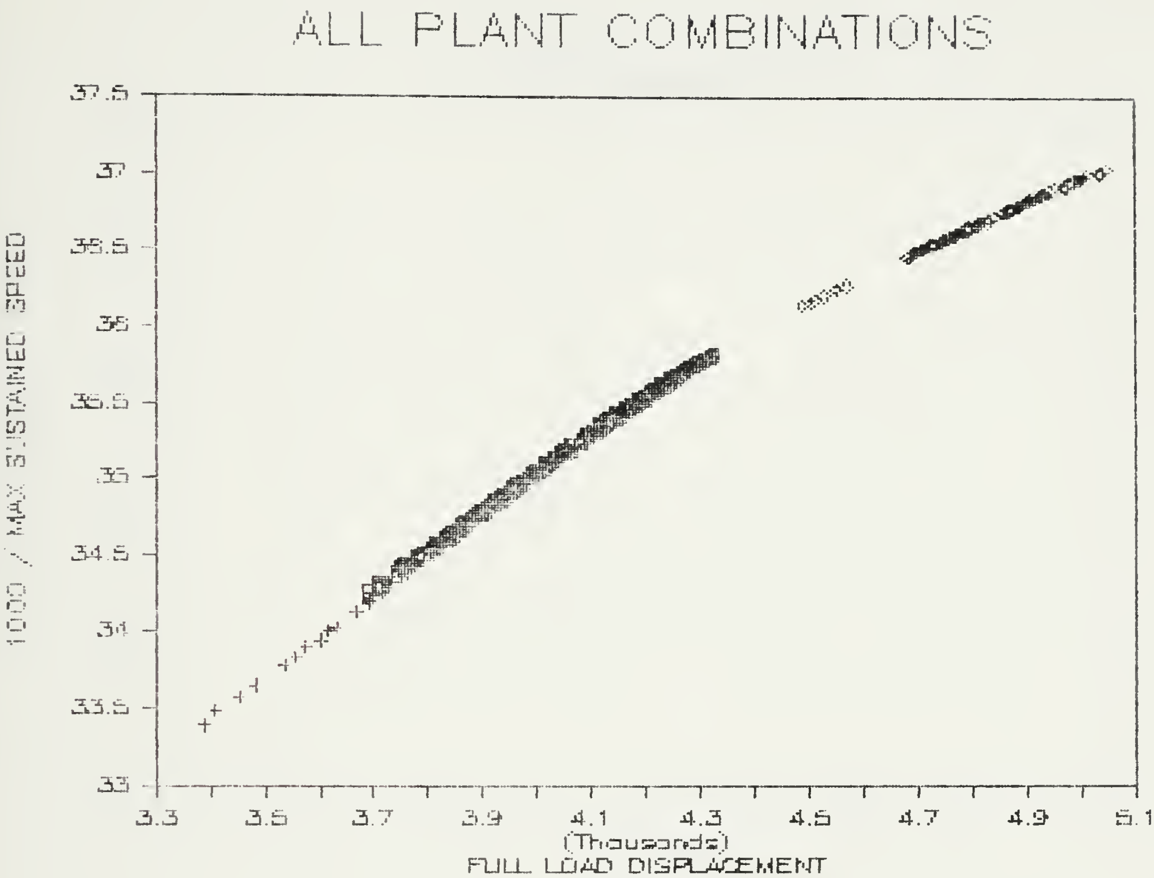
The concept with the lowest value for W300 / KW is a steam generator with a high speed diesel emergency generator. After examining the dominant and inferior options, it is apparent that this attribute is the only attribute which kept no emergency generator from being a dominant option. It also becomes clear that the requirement for an emergency electrical plant is driving the increase in the other attributes. Given this additional information and the

knowledge that all possible combinations of electrical plants have been synthesized, the decision maker is better able to select a concept or to at least eliminate some of the concepts.

The redundant attributes for the steam case are listed below:

column 15 ==> COST
column 14 ==> W200 + W300
column 11 ==> INTERNAL VOLUME

It is important to note that the redundant attributes are different for the case when all the data is analyzed and when just the steam data is analyzed. This can provide valuable information to the decision maker. For example, there is a tendency in ship design to say cost is a surrogate of displacement. The analysis indicates that in this particular case that is true. However, in looking at the linear relationship between displacement and 1000 / Vs, the indication is that these two attributes would be redundant. The analysis shows they are redundant for pass one and two but not redundant for pass three.



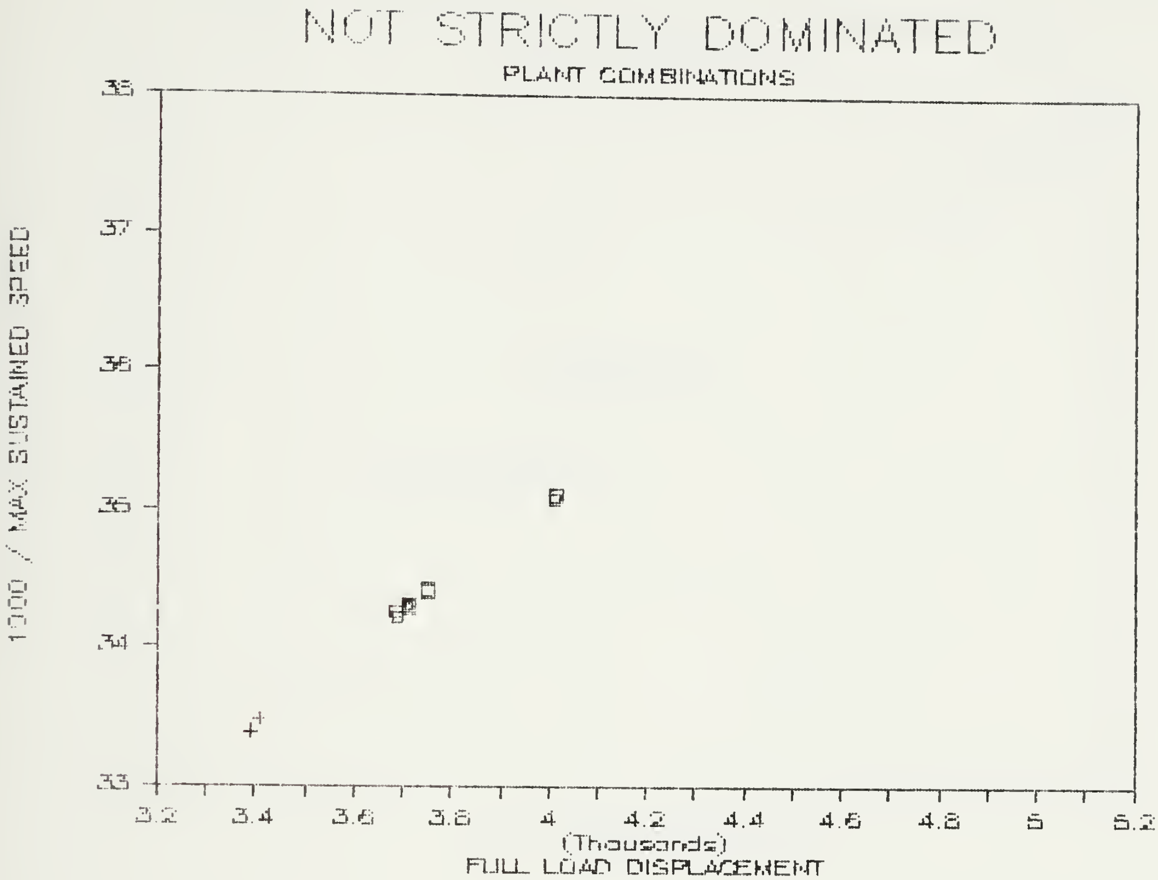
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

<> DIESEL PROPULSION PLANTS

FIGURE 4.1

DISPLACEMENT VS 1000 / MAX SUSTAINED SPEED



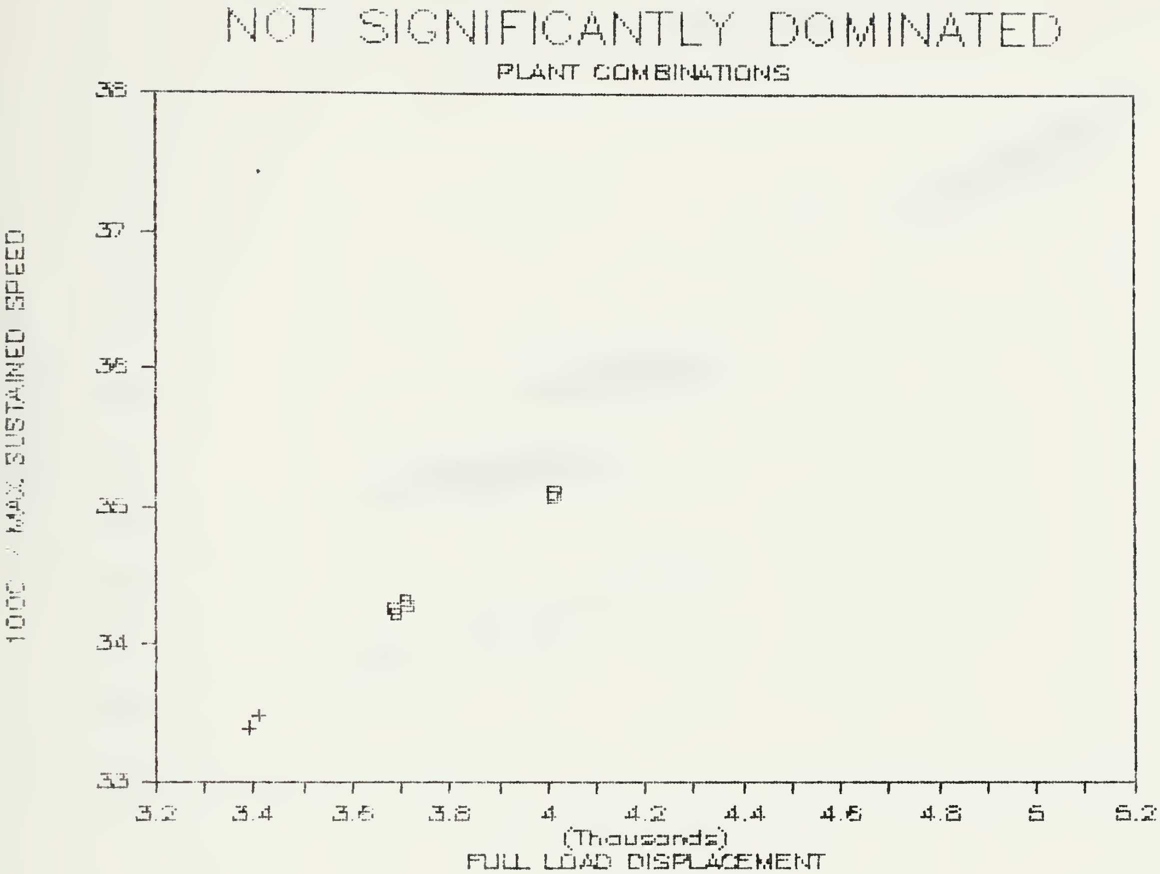
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.1.b

NOT STRICTLY DOMINATED

DISPLACEMENT VS 1000 / MAX SUSTAINED SPEED



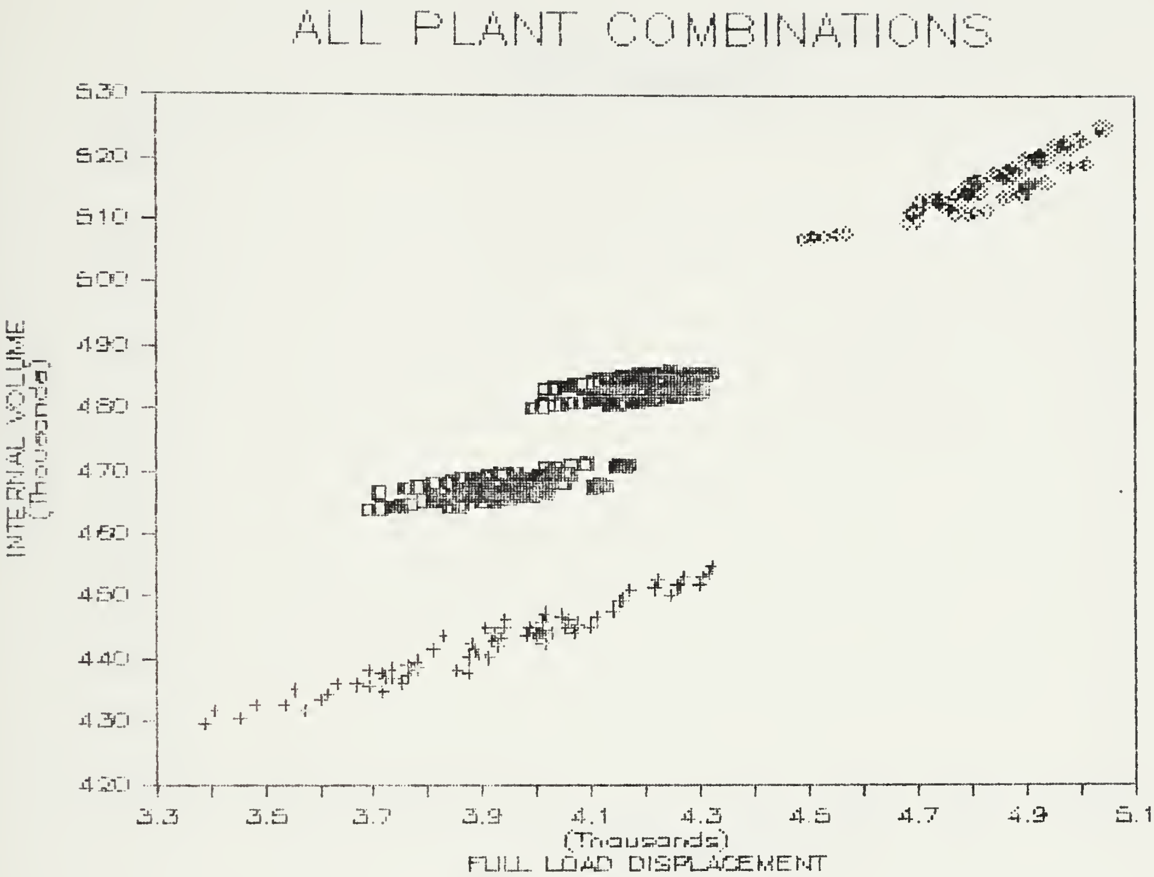
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.1.c

NOT SIGNIFICANTLY DOMINATED

DISPLACEMENT VS 1000 / MAX SUSTAINED SPEED



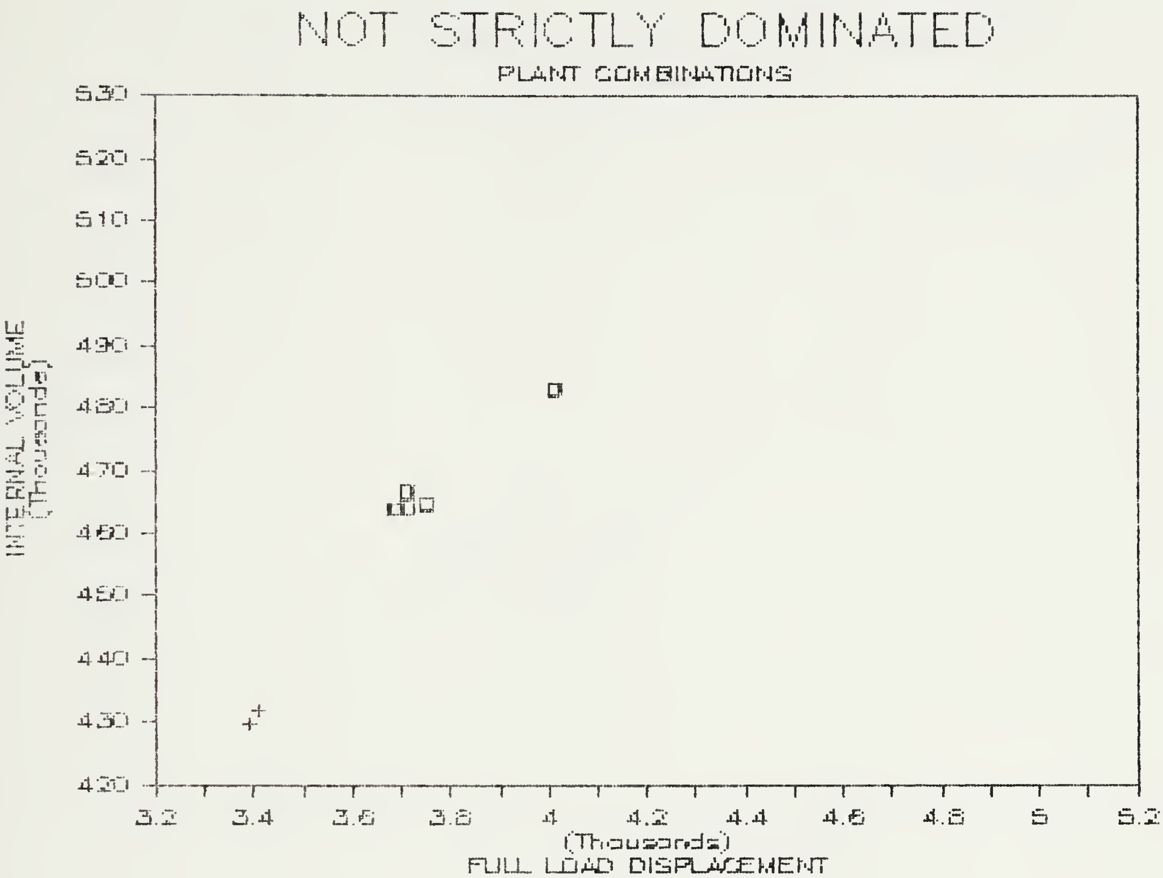
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

<> DIESEL PROPULSION PLANTS

FIGURE 4.2

DISPLACEMENT VS INTERNAL VOLUME



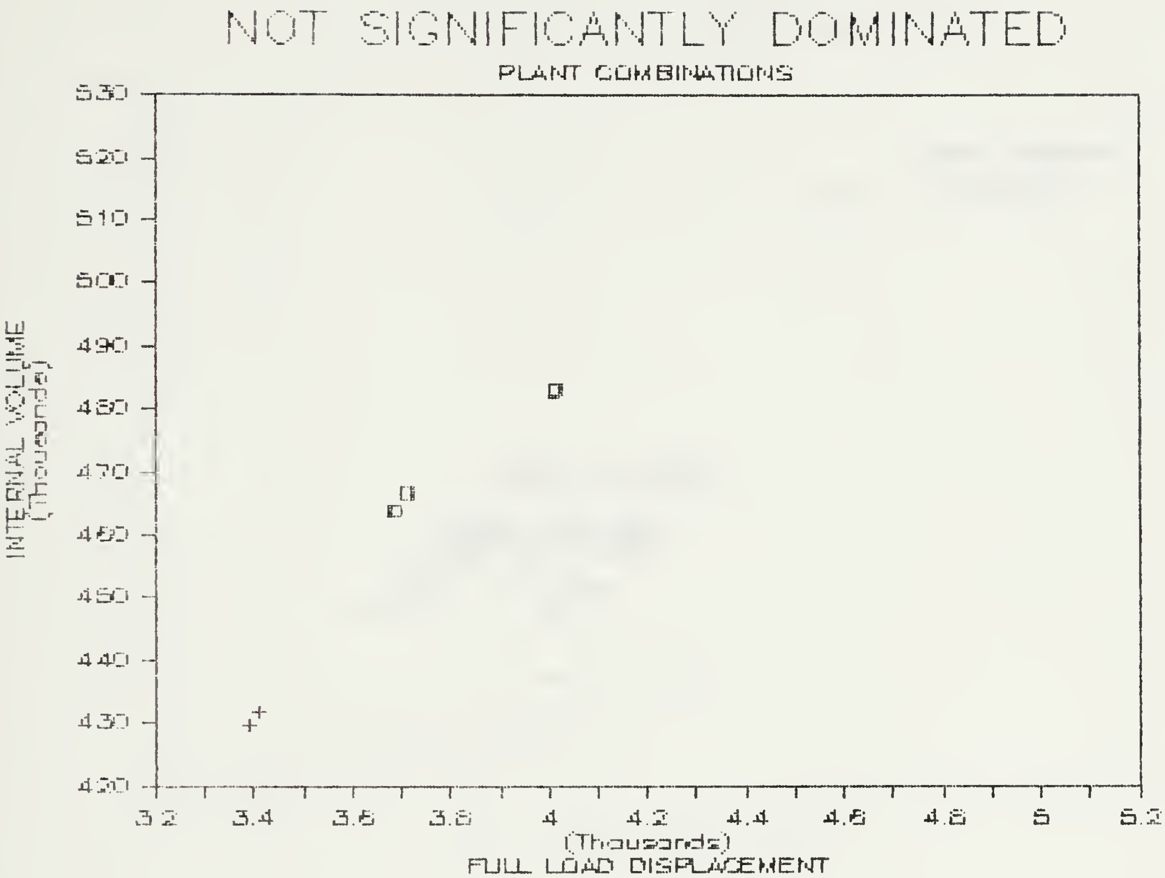
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.2.b

NOT STRICTLY DOMINATED

DISPLACEMENT VS INTERNAL VOLUME



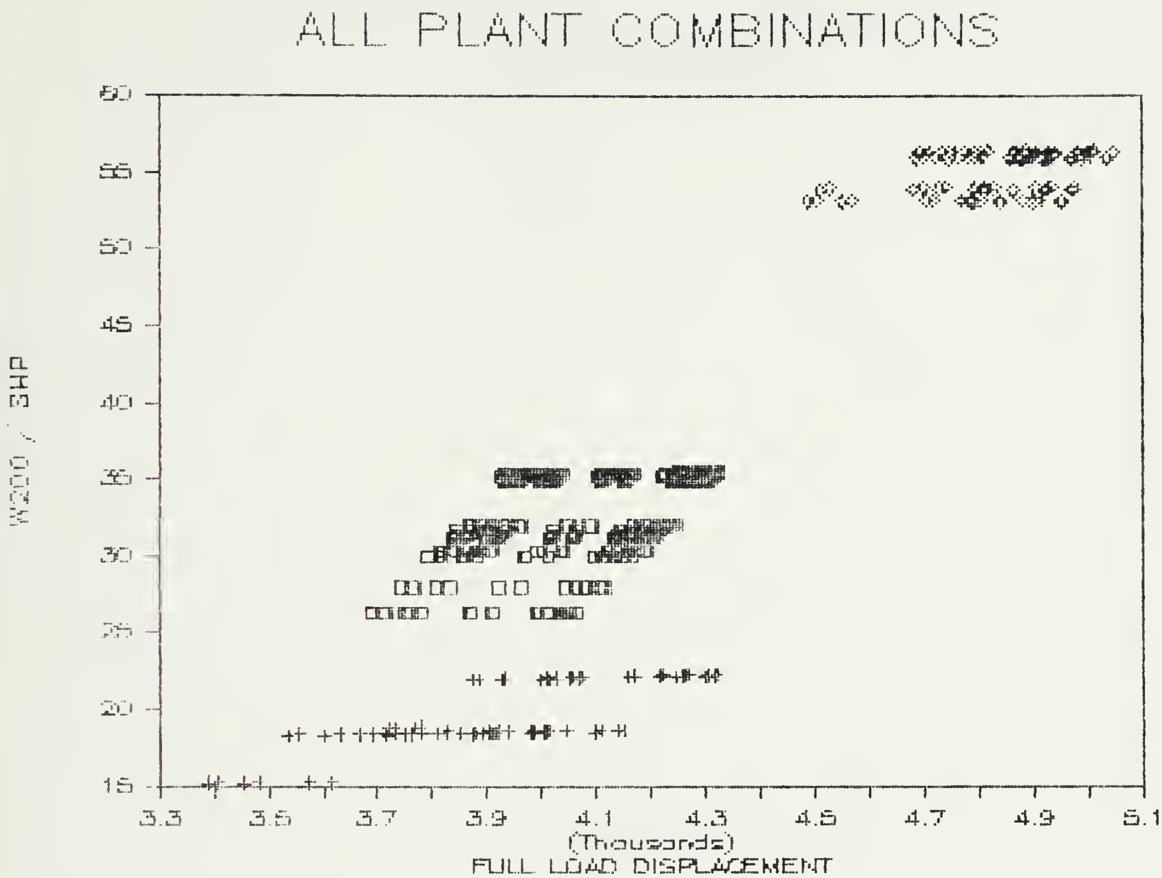
+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.2.c

NOT SIGNIFICANTLY DOMINATED

DISPLACEMENT VS INTERNAL VOLUME



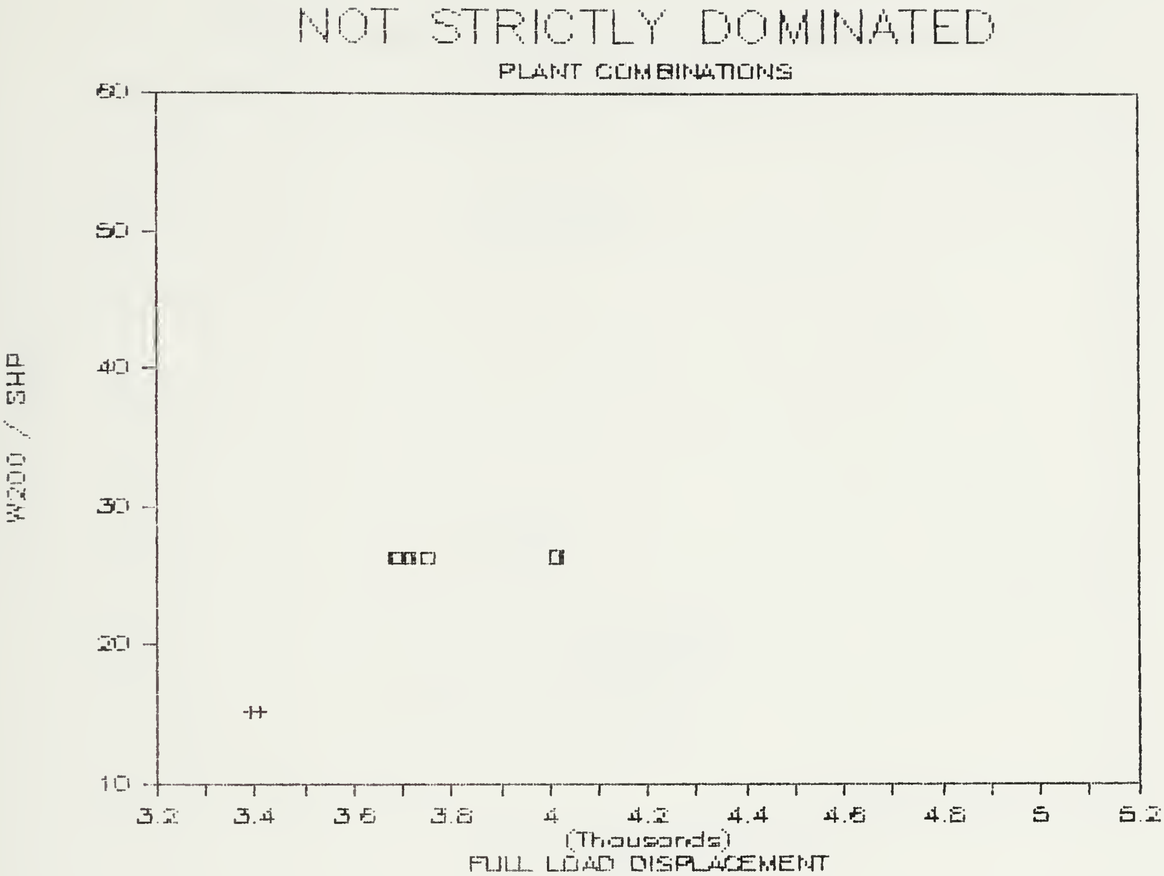
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

<> DIESEL PROPULSION PLANTS

FIGURE 4.3

DISPLACEMENT VS W200 / SHP



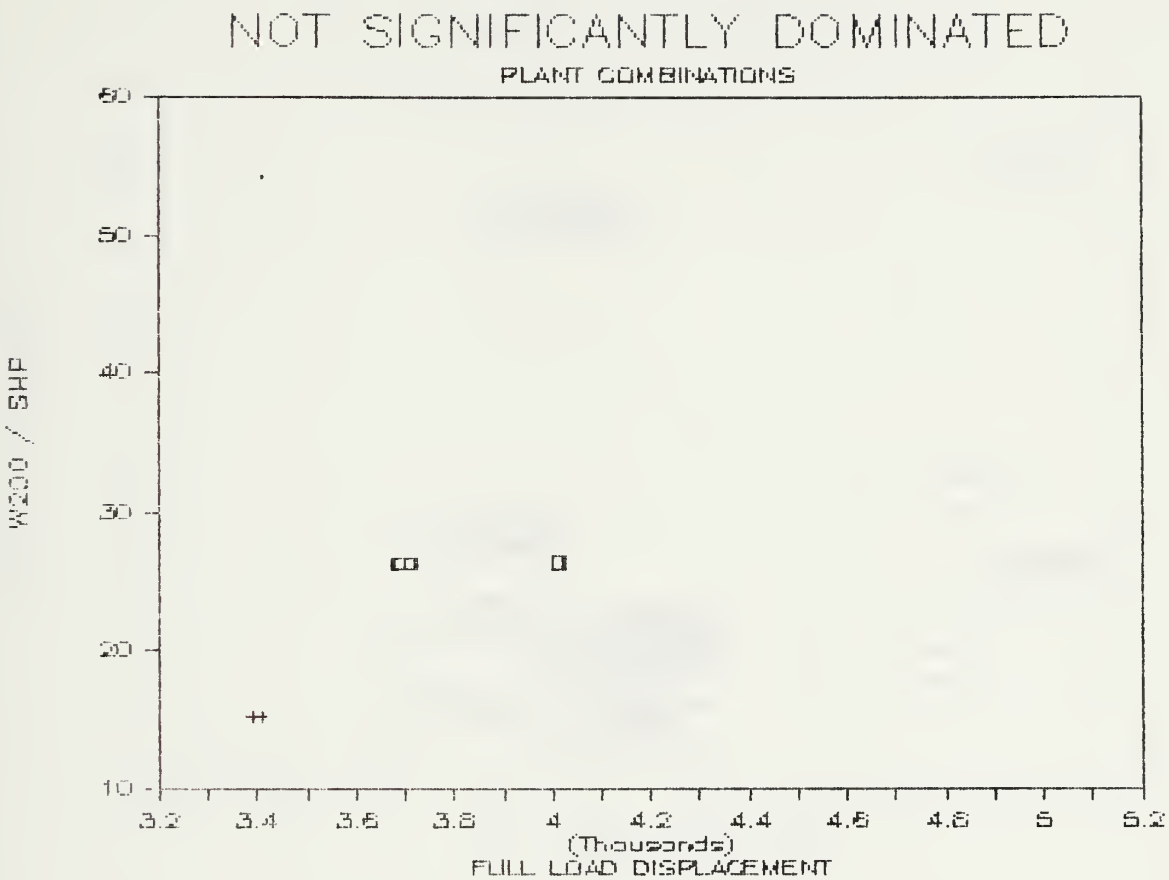
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.3.b

NOT STRICTLY DOMINATED

DISPLACEMENT VS W200 / SHP



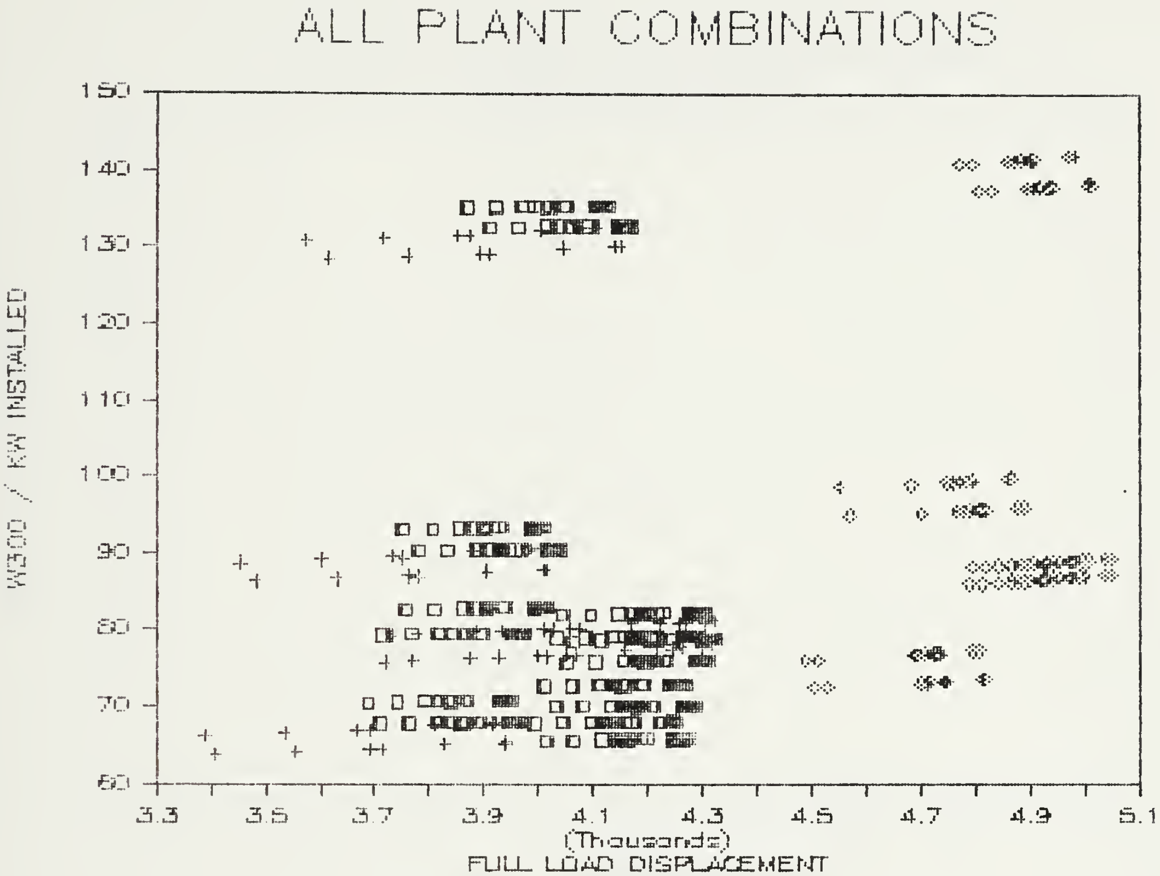
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.3.c

NOT SIGNIFICANTLY DOMINATED

DISPLACEMENT VS W200 / SHP



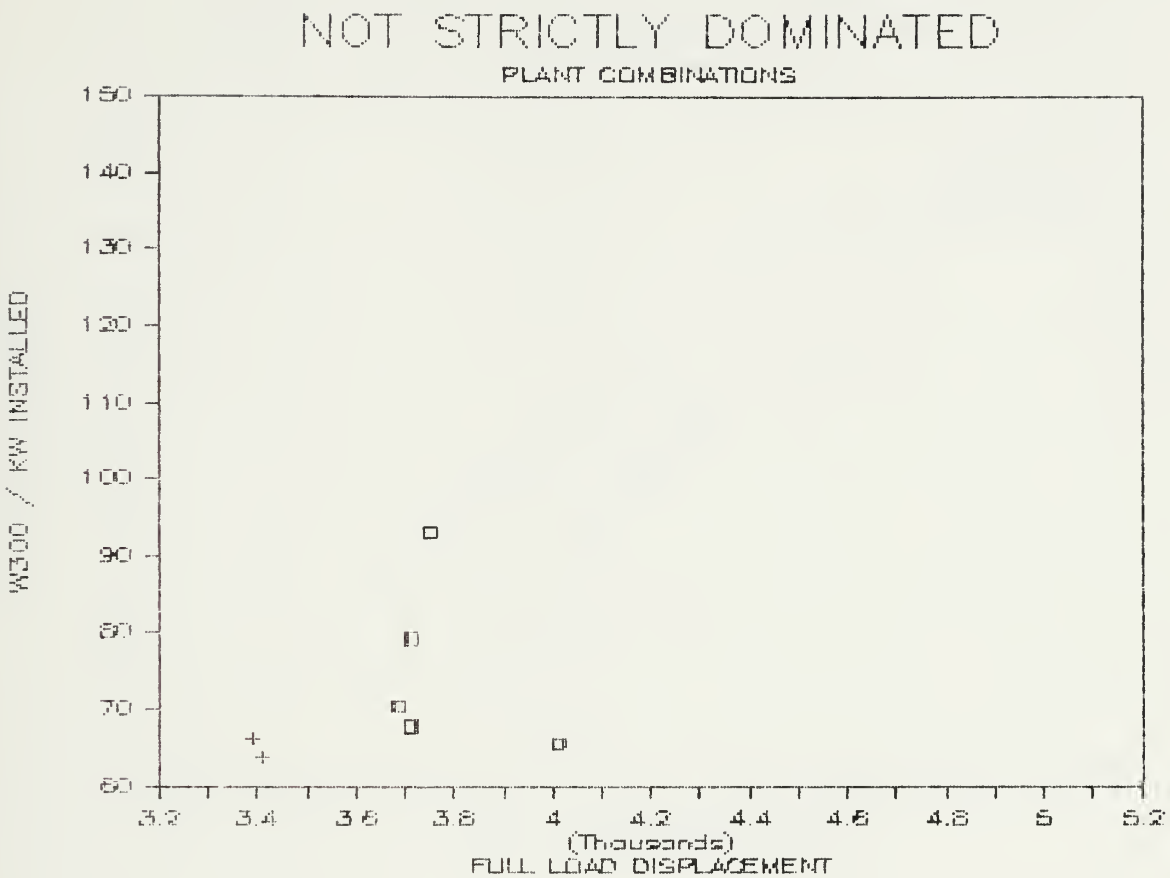
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

<> DIESEL PROPULSION PLANTS

FIGURE 4.4

DISPLACEMENT VS W300 / KW



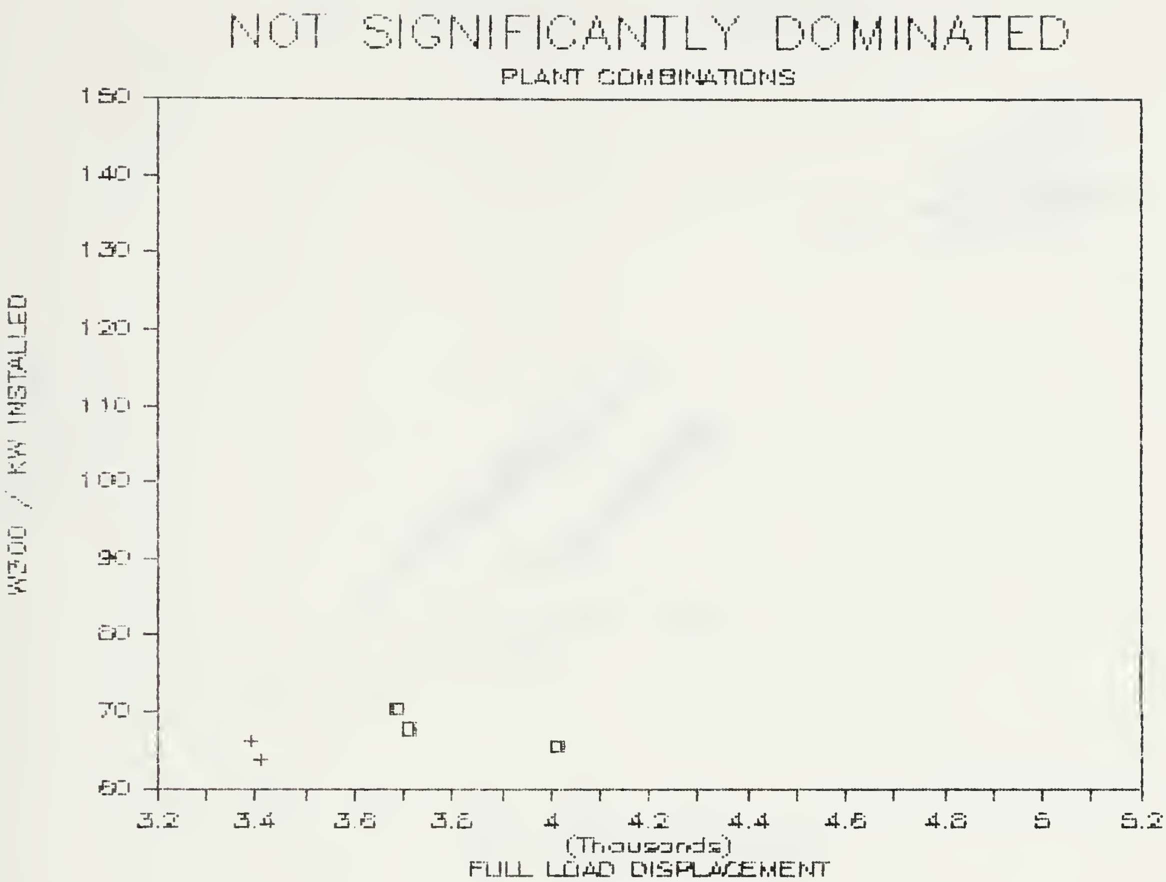
+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.4.b

NOT STRICTLY DOMINATED

DISPLACEMENT VS W300 / KW



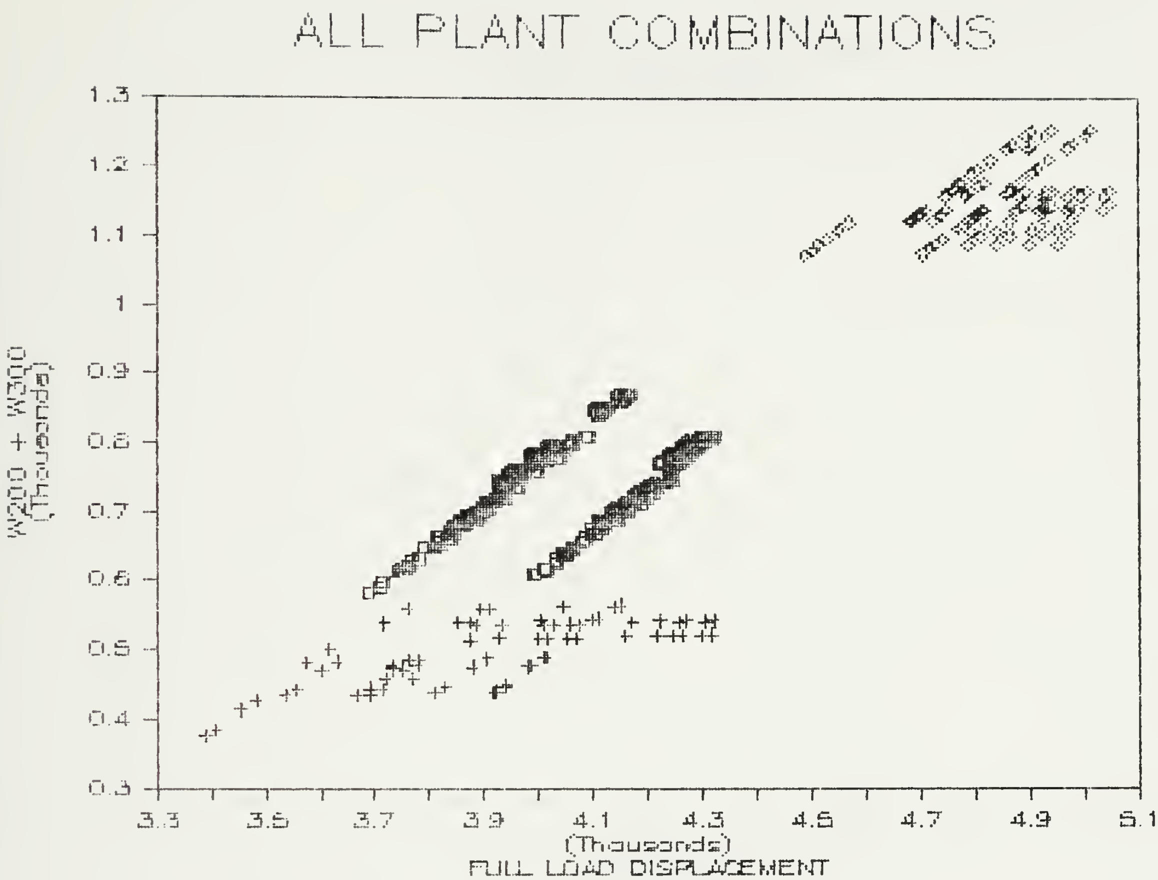
+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.4.c

NOT SIGNIFICANTLY DOMINATED

DISPLACEMENT VS W300 / KW



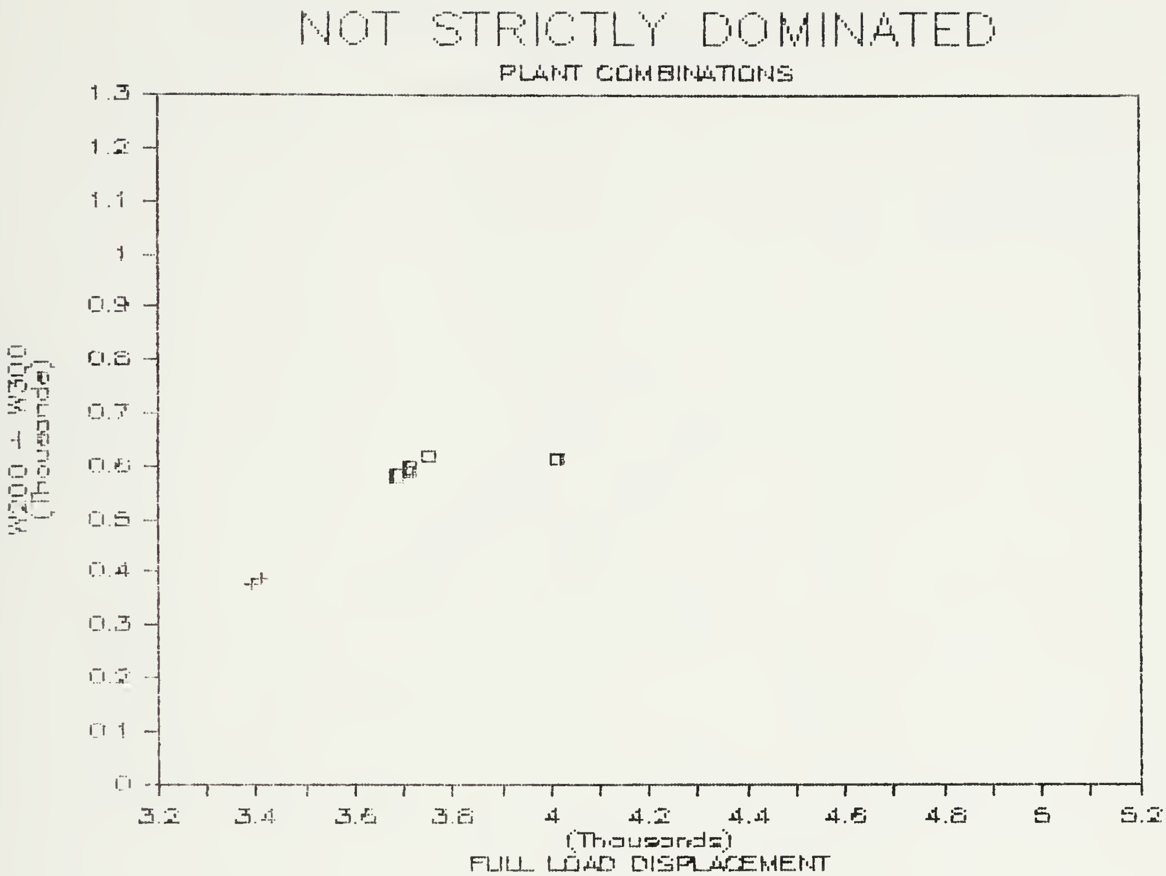
+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

<> DIESEL PROPULSION PLANTS

FIGURE 4.5

DISPLACEMENT VS W200 + W300



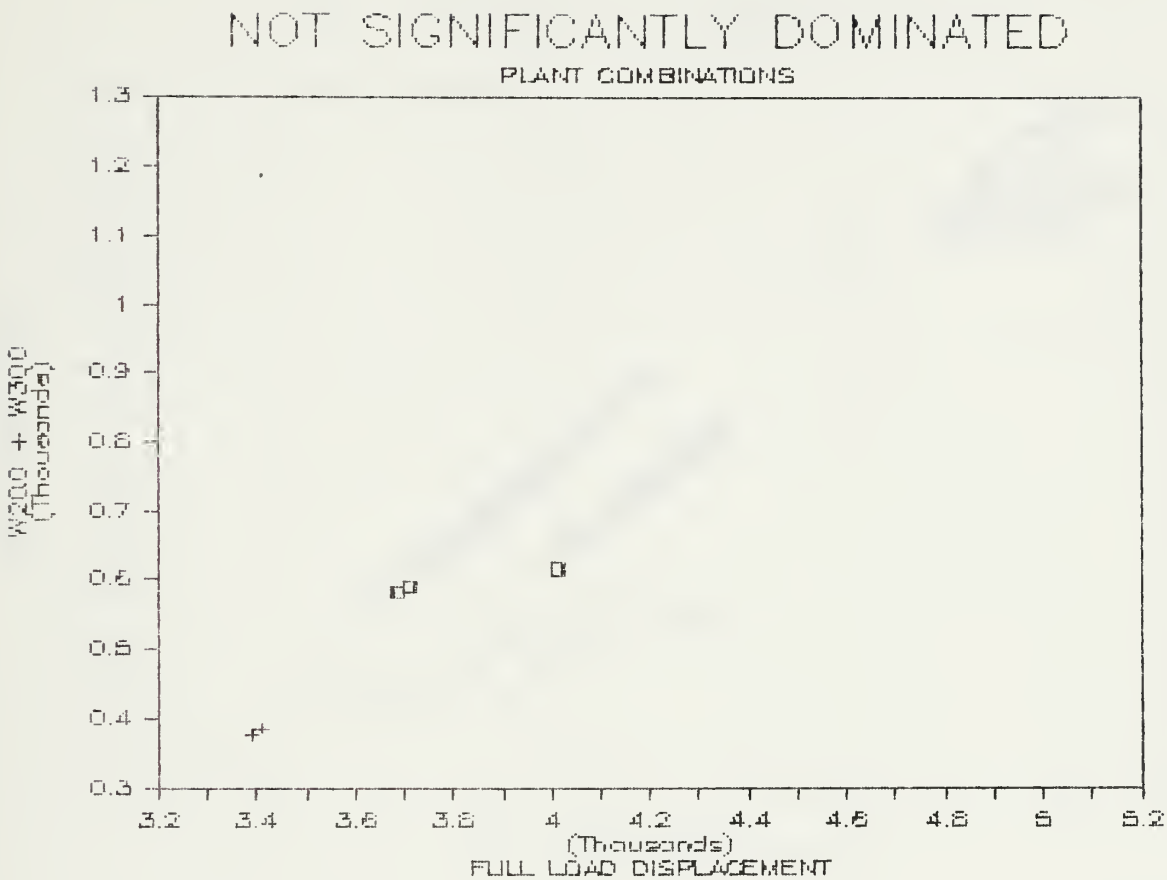
+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.5.b

NOT STRICTLY DOMINATED

DISPLACEMENT VS W200 + W300



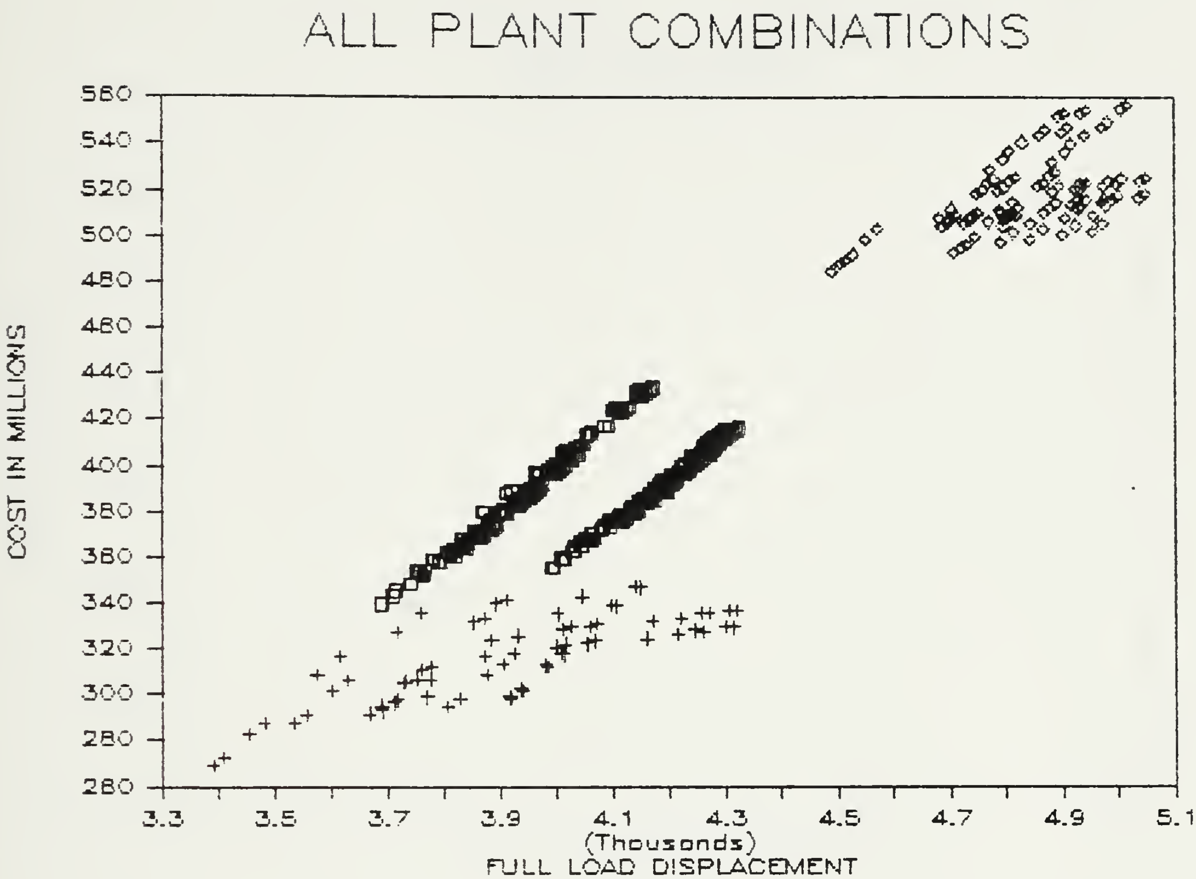
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.5.c

NOT SIGNIFICANTLY DOMINATED

DISPLACEMENT VS W200 + W300



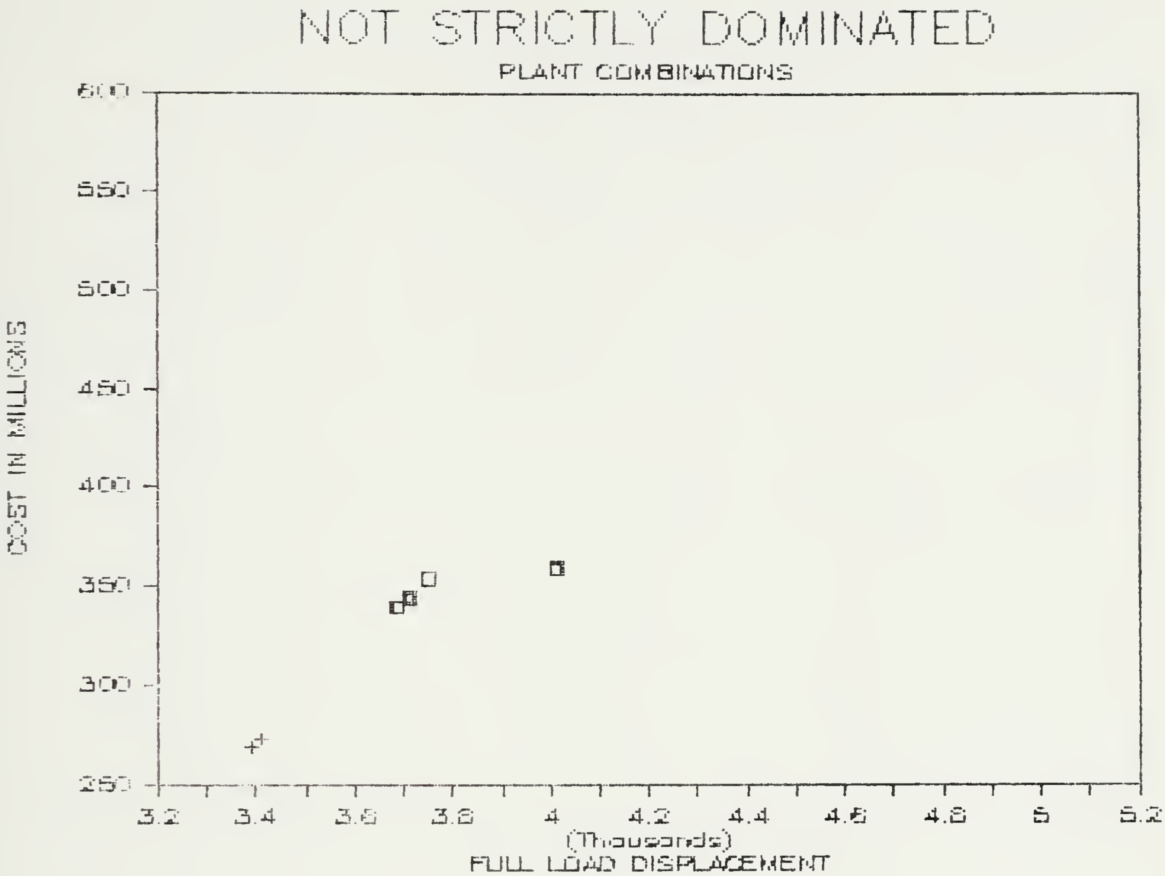
\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

<> DIESEL PROPULSION PLANTS

FIGURE 4.6

DISPLACEMENT VS COST



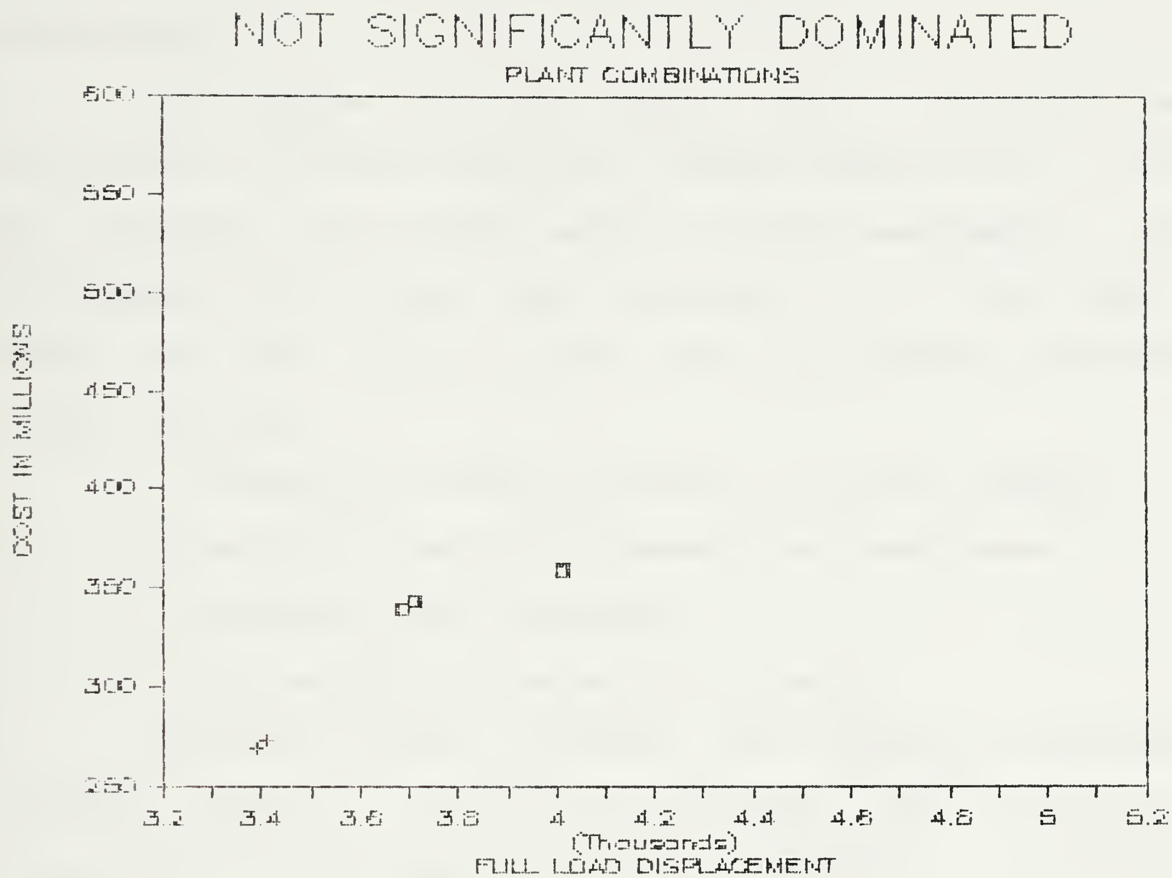
+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.6.b

NOT STRICTLY DOMINATED

DISPLACEMENT VS COST



\+ GAS TURBINE PROPULSION PLANTS

[] STEAM PROPULSION PLANTS

FIGURE 4.6.c

NOT SIGNIFICANTLY DOMINATED

DISPLACEMENT VS COST

Chapter 5

CONCLUSIONS

The purpose of this thesis was to evaluate the usefulness of Multiple Attribute Tradeoff Analysis as a tool for managers and decision makers in naval ship design. The methodology was proposed and validated in a case study. There are four initial areas where the analysis could be readily applied:

1) conducting tradeoff analysis on current designs
2) analyzing trends for research and development
3) evaluating new technology
4) evaluating ship conversion projects

On current design projects the Multiple Attribute Tradeoff Analysis provides the designer with a method of evaluating a large number of different concepts. Therefore the designer is free to investigate the maximum number of different combinations of systems and subsystems during early stage design. Through the use of graphs and tables the analysis can indicate the boundary between possible and unachievable values for the attributes. As the design progresses, the analysis can identify redundant attributes and noncritical uncertainties to help the decision maker focus on the real issues. Also, knowing the redundant attributes and noncritical uncertainties can aide the decision maker in applying utility functions. Finally, the analysis can be used to evaluate the effect of varying the

internal values of the utility function to reflect the priorities of the different decision makers.

In the area of research and development, Multiple Attribute Tradeoff Analysis can identify dominant and inferior options. Therefore, if several systems or subsystems prove to be dominant in a variety of concepts more research and development could be directed toward improving or enhancing these systems. Also, the analysis could be used to investigate the impact on ship design of developing a new system such as a 50,000 SHP gas turbine or the best systems to integrate with a 50,000 SHP turbine. If the subsystems and systems to be integrated are known in advance, the component can be designed to accommodate the integration and a savings in weight and volume can be achieved.

Research and development goes hand in hand with the evaluation of new technology. In order to evaluate a new component, subsystem, or system it needs to be coupled with a full range of old and new system concepts. The risk and uncertainties associated with new technology need to be identified and reduced. The Multiple Attribute Tradeoff Analysis provides a tool for evaluating a large number of system concepts and identifing noncritical uncertainties. It can also point out the best systems and subsystems to couple with a new concept so integration problems can be determined and worked out. Therefore, much of the risk associated with new technology can be identified and eliminated early in the design process or before the technology is incorporated in a

current design.

Finally, one of the most difficult challenges facing a naval architect is the conversion or modernization of an older ship. Often the growth and service life margins have been used up. For example, the ship may have reached its stability limit or its full load displacement limit and a new system needs to be added. Through the use of Multiple Attribute Tradeoff Analysis a wide variety of alternative methods of achieving the conversion can be evaluated. Also, by careful selection of the attributes, the analysis can look for the concepts which have the minimum impact on the service life margins. Therefore, the architect may be able to find a method to accomplish a conversion that could not otherwise be done.

The Multiple Attribute Tradeoff Analysis is not being proposed as a sole method of conducting tradeoff studies. It is being proposed as a useful tool that can aid the decision maker at all stages of the ship design process. There are advantages and disadvantages of this methodology.

The advantages are:

1) a large number of concepts can be easily evaluated

2) the relative "goodness" of each concept is represented without being clouded by weighting factors

3) the boundaries between possible and unachievable values of the attributes can be identified

4) donimant and inferior options can be easily identified

5) noncritical uncertainties and redundant attributes are identified

The disadvantages are:

1) at some point a weighting factor has to be assigned the attributes before a final decision can be made

2) although large complicated synthesis models are not a requirement there is a need for estimating relationships for all concepts being evaluated

3) in order to evaluate the impact of new technology on a ship design algrithms need to be developed and incorporated in ship synthesis models

In comparing the current methodology with the Multiple Attribute Tradeoff Analysis methodology it can be seen that both are useful. The current method provides a means of incorporating weighting factors with the attributes and provides a scalar value representing the concept which best reflects the priorities of the decision maker. The proposed method provides the decision maker with clear understanding of the critical uncertainties and relevant attributes. Therefore the decision maker is in a better position to apply the utility functions to incorporate the weighting factors. No one method is best and a combination of methods would prove to be the most useful in the ship design process.

REFERENCES

[1] Woodward-Clyde Consultants, "Decision Framework For Technology Choice Vol. 1: A Case Study of One Utility's Coal-Nuclear Choice", Funded By Electric Power Research Institute, EA-2153, Research Project 1433-1, Dec. 1981

[2] Kramer, R. P., "Analytic Heirarchy Process Decision Model", unpublished

[3] Goddard, C. H., "A Methodology For Technology Characterization and Evaluation For Naval Ships," MIT O.E. Thesis June 1985

[4] Merrill, H. M., Schweppe, F. C., White, D. C., "Energy Strategy Planning For Electric Utilities Part 1, Smarte Methodology," IEEE Transactions On Power Apparatus and Systems, Vol. Pas-101, No. 2 Feb. 1982

[5] Aperjis, D., et al, "Energy Strategy Planning For Electric Utilities Part 2, Smarte Methodology," IEEE Transactions On Power Apparatus and Systems, Vol. Pas-101, No. 2 Feb. 1982

[6] Schweppe, F. C., "Multiple Attribute Tradeoff Analysis," Electric Power Research Institute, RP 2537, unpublished

[7] Reed, M. R., "Ship Synthesis Model For Naval Surface Ships," MIT O.E. Thesis May 1976

APPENDIX I

LIST OF OPTIONS USED IN CASE STUDY

KEY FOR THE CODES USED IN THE LIST OF OPTIONS

Type of Propulsion Plant
1. 600 lb steam
2. 1200 lb steam
3. 1200 lb pressure fired steam
4. 1st generation gas turbines
5. 2nd generation gas turbines
6. Diesel engines
    a. low speed
    b. medium speed
    c. high speed

Number of Boilers
1. 1, 2, or 3 with one shaft
2. 2, 3, or 4 with two shafts

Number of Engines
1. 1 or 2 with steam plants
2. 1, 2, 3, or 4 with gas turbine and diesel plants

Number of Shafts (1 or 2)

Type of Propeller
1. fixed pitch
2. controllable pitch

Ship Service Electrical Generators
1. steam in conjunction with a steam plant
2. 1st generation gas turbine
3. 2nd generation gas turbine
4. low speed diesel
5. medium speed diesel
6. high speed diesel

Emergency Electrical Generators (steam plants only)
1. 1st generation gas turbine
2. 2nd generation gas turbine
3. low speed diesel
4. medium speed diesel
5. high speed diesel

Number of Ship Service Generators (3 or 4)

LIST OF ABBREVIATIONS USED IN APPENDIX I

SHIP NUM - Ship Reference Number

PROP PLT - Propulsion Plant Type

NB - Number of Boilers

NE - Number of Main Engines

NSHFT - Number of Shafts

PRP TYP - Type of Propeller

SSE TYP - Type of Ship Service Electrical Generators

EME TYP - Type of Emergency Electrical Generators

NU LSD - Number of Low Speed Diesels

NU MSD - Number of Medium Speed Diesels

NU HSD - Number of High Speed Diesels

NU GTG - Number of Gas Turbine Generators

NU STG - Number of Steam Generators

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
2	1.0	1.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
3	1.0	1.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
4	1.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
5	1.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
6	1.0	1.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
7	1.0	1.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
8	1.0	1.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
9	1.0	1.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
10	1.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
11	1.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
12	1.0	1.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
13	1.0	1.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
14	1.0	1.0	1.0	1.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
15	1.0	1.0	1.0	1.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
16	1.0	1.0	1.0	1.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
17	1.0	1.0	1.0	1.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
18	1.0	1.0	1.0	1.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
19	1.0	1.0	1.0	1.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
20	1.0	1.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
21	1.0	1.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
22	1.0	1.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
23	1.0	1.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
24	1.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
25	1.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
26	1.0	1.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
27	1.0	1.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
28	1.0	1.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
29	1.0	1.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
30	1.0	1.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
31	1.0	1.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
32	1.0	1.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
33	1.0	1.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
34	1.0	1.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
35	1.0	1.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
36	1.0	1.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
37	1.0	1.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
38	1.0	1.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
39	1.0	1.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
40	1.0	2.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
41	1.0	2.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
42	1.0	2.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
43	1.0	2.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
44	1.0	2.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
45	1.0	2.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
46	1.0	2.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
47	1.0	2.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
48	1.0	2.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
49	1.0	2.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
50	1.0	2.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	3.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
51	1.0	2.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
52	1.0	2.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
53	1.0	2.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
54	1.0	2.0	1.0	1.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
55	1.0	2.0	1.0	1.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
56	1.0	2.0	1.0	1.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
57	1.0	2.0	1.0	1.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
58	1.0	2.0	1.0	1.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
59	1.0	2.0	1.0	1.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
60	1.0	2.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
61	1.0	2.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
62	1.0	2.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
63	1.0	2.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
64	1.0	2.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
65	1.0	2.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
66	1.0	2.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
67	1.0	2.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
68	1.0	2.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
69	1.0	2.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
70	1.0	2.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
71	1.0	2.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
72	1.0	2.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
73	1.0	2.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
74	1.0	2.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
75	1.0	2.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
76	1.0	2.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
77	1.0	2.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
78	1.0	2.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
79	1.0	2.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
80	1.0	2.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
81	1.0	2.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
82	1.0	2.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
83	1.0	2.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
84	1.0	2.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
85	1.0	2.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
86	1.0	2.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
87	1.0	2.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
88	1.0	2.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
89	1.0	2.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
90	1.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
91	1.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
92	1.0	2.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
93	1.0	2.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
94	1.0	2.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
95	1.0	2.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
96	1.0	2.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
97	1.0	2.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
98	1.0	2.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
99	1.0	2.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
100	1.0	2.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
101	1.0	2.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
102	1.0	2.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
103	1.0	2.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
104	1.0	2.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
105	1.0	2.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
106	1.0	2.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
107	1.0	2.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
108	1.0	2.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
109	1.0	2.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
110	1.0	2.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
111	1.0	2.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
112	1.0	2.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
113	1.0	2.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
114	1.0	2.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
115	1.0	2.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
116	1.0	2.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
117	1.0	2.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
118	1.0	2.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
119	1.0	2.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
120	1.0	3.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
121	1.0	3.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
122	1.0	3.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
123	1.0	3.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
124	1.0	3.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
125	1.0	3.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
126	1.0	3.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
127	1.0	3.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
128	1.0	3.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
129	1.0	3.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
130	1.0	3.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
131	1.0	3.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
132	1.0	3.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
133	1.0	3.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
134	1.0	3.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
135	1.0	3.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
136	1.0	3.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
137	1.0	3.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
138	1.0	3.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
139	1.0	3.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
140	1.0	3.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
141	1.0	3.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
142	1.0	3.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
143	1.0	3.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
144	1.0	3.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
145	1.0	3.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
146	1.0	3.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
147	1.0	3.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
148	1.0	3.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
149	1.0	3.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
150	1.0	3.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
151	1.0	3.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
152	1.0	3.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
153	1.0	3.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
154	1.0	3.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
155	1.0	3.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
156	1.0	3.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
157	1.0	3.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
158	1.0	3.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
159	1.0	3.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
160	1.0	4.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
161	1.0	4.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
162	1.0	4.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
163	1.0	4.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
164	1.0	4.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
165	1.0	4.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
166	1.0	4.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
167	1.0	4.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
168	1.0	4.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
169	1.0	4.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
170	1.0	4.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
171	1.0	4.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
172	1.0	4.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
173	1.0	4.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
174	1.0	4.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
175	1.0	4.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
176	1.0	4.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
177	1.0	4.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
178	1.0	4.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
179	1.0	4.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
180	1.0	4.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
181	1.0	4.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
182	1.0	4.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
183	1.0	4.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
184	1.0	4.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
185	1.0	4.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
186	1.0	4.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
187	1.0	4.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
188	1.0	4.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
189	1.0	4.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
190	1.0	4.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
191	1.0	4.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
192	1.0	4.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
193	1.0	4.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
194	1.0	4.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
195	1.0	4.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
196	1.0	4.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
197	1.0	4.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
198	1.0	4.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
199	1.0	4.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
200	2.0	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
201	2.0	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
202	2.0	1.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
203	2.0	1.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
204	2.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
205	2.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
206	2.0	1.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
207	2.0	1.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
208	2.0	1.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
209	2.0	1.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
210	2.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
211	2.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
212	2.0	1.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
213	2.0	1.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
214	2.0	1.0	1.0	1.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
215	2.0	1.0	1.0	1.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
216	2.0	1.0	1.0	1.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
217	2.0	1.0	1.0	1.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
218	2.0	1.0	1.0	1.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
219	2.0	1.0	1.0	1.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
220	2.0	1.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
221	2.0	1.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
222	2.0	1.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
223	2.0	1.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
224	2.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
225	2.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
226	2.0	1.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
227	2.0	1.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
228	2.0	1.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
229	2.0	1.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
230	2.0	1.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
231	2.0	1.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
232	2.0	1.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
233	2.0	1.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
234	2.0	1.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
235	2.0	1.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
236	2.0	1.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
237	2.0	1.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
238	2.0	1.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
239	2.0	1.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
240	2.0	2.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
241	2.0	2.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
242	2.0	2.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
243	2.0	2.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
244	2.0	2.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
245	2.0	2.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
246	2.0	2.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
247	2.0	2.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
248	2.0	2.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
249	2.0	2.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
250	2.0	2.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	3.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
251	2.0	2.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
252	2.0	2.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
253	2.0	2.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
254	2.0	2.0	1.0	1.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
255	2.0	2.0	1.0	1.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
256	2.0	2.0	1.0	1.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
257	2.0	2.0	1.0	1.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
258	2.0	2.0	1.0	1.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
259	2.0	2.0	1.0	1.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
260	2.0	2.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
261	2.0	2.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
262	2.0	2.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
263	2.0	2.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
264	2.0	2.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
265	2.0	2.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
266	2.0	2.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
267	2.0	2.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
268	2.0	2.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
269	2.0	2.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
270	2.0	2.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
271	2.0	2.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
272	2.0	2.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
273	2.0	2.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
274	2.0	2.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
275	2.0	2.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
276	2.0	2.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
277	2.0	2.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
278	2.0	2.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
279	2.0	2.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
280	2.0	2.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
281	2.0	2.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
282	2.0	2.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
283	2.0	2.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
284	2.0	2.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
285	2.0	2.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
286	2.0	2.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
287	2.0	2.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
288	2.0	2.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
289	2.0	2.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
290	2.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
291	2.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
292	2.0	2.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
293	2.0	2.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
294	2.0	2.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
295	2.0	2.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
296	2.0	2.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
297	2.0	2.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
298	2.0	2.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
299	2.0	2.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
300	2.0	2.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
301	2.0	2.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
302	2.0	2.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
303	2.0	2.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
304	2.0	2.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
305	2.0	2.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
306	2.0	2.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
307	2.0	2.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
308	2.0	2.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
309	2.0	2.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
310	2.0	2.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
311	2.0	2.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
312	2.0	2.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
313	2.0	2.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
314	2.0	2.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
315	2.0	2.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
316	2.0	2.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
317	2.0	2.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
318	2.0	2.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
319	2.0	2.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
320	2.0	3.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
321	2.0	3.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
322	2.0	3.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
323	2.0	3.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
324	2.0	3.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
325	2.0	3.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
326	2.0	3.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
327	2.0	3.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
328	2.0	3.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
329	2.0	3.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
330	2.0	3.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
331	2.0	3.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
332	2.0	3.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
333	2.0	3.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
334	2.0	3.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
335	2.0	3.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
336	2.0	3.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
337	2.0	3.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
338	2.0	3.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
339	2.0	3.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
340	2.0	3.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
341	2.0	3.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
342	2.0	3.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
343	2.0	3.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
344	2.0	3.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
345	2.0	3.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
346	2.0	3.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
347	2.0	3.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
348	2.0	3.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
349	2.0	3.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
350	2.0	3.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
351	2.0	3.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
352	2.0	3.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
353	2.0	3.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
354	2.0	3.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
355	2.0	3.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
356	2.0	3.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
357	2.0	3.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
358	2.0	3.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
359	2.0	3.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
360	2.0	4.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
361	2.0	4.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
362	2.0	4.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
363	2.0	4.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
364	2.0	4.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
365	2.0	4.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
366	2.0	4.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
367	2.0	4.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
368	2.0	4.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
369	2.0	4.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
370	2.0	4.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
371	2.0	4.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
372	2.0	4.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
373	2.0	4.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
374	2.0	4.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
375	2.0	4.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
376	2.0	4.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
377	2.0	4.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
378	2.0	4.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
379	2.0	4.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
380	2.0	4.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
381	2.0	4.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
382	2.0	4.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
383	2.0	4.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
384	2.0	4.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
385	2.0	4.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
386	2.0	4.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
387	2.0	4.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
388	2.0	4.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
389	2.0	4.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
390	2.0	4.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
391	2.0	4.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
392	2.0	4.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
393	2.0	4.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
394	2.0	4.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
395	2.0	4.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
396	2.0	4.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
397	2.0	4.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
398	2.0	4.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
399	2.0	4.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
400	3.0	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
401	3.0	1.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
402	3.0	1.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
403	3.0	1.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
404	3.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
405	3.0	1.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
406	3.0	1.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
407	3.0	1.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
408	3.0	1.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
409	3.0	1.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
410	3.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
411	3.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
412	3.0	1.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
413	3.0	1.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
414	3.0	1.0	1.0	1.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
415	3.0	1.0	1.0	1.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
416	3.0	1.0	1.0	1.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
417	3.0	1.0	1.0	1.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
418	3.0	1.0	1.0	1.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
419	3.0	1.0	1.0	1.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
420	3.0	1.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
421	3.0	1.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
422	3.0	1.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
423	3.0	1.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
424	3.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
425	3.0	1.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
426	3.0	1.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
427	3.0	1.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
428	3.0	1.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
429	3.0	1.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
430	3.0	1.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
431	3.0	1.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
432	3.0	1.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
433	3.0	1.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
434	3.0	1.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
435	3.0	1.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
436	3.0	1.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
437	3.0	1.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
438	3.0	1.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
439	3.0	1.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
440	3.0	2.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
441	3.0	2.0	1.0	1.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
442	3.0	2.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
443	3.0	2.0	1.0	1.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
444	3.0	2.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
445	3.0	2.0	1.0	1.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
446	3.0	2.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
447	3.0	2.0	1.0	1.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
448	3.0	2.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
449	3.0	2.0	1.0	1.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
450	3.0	2.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	3.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
451	3.0	2.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
452	3.0	2.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
453	3.0	2.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
454	3.0	2.0	1.0	1.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
455	3.0	2.0	1.0	1.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
456	3.0	2.0	1.0	1.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
457	3.0	2.0	1.0	1.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
458	3.0	2.0	1.0	1.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
459	3.0	2.0	1.0	1.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
460	3.0	2.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
461	3.0	2.0	1.0	1.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
462	3.0	2.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
463	3.0	2.0	1.0	1.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
464	3.0	2.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
465	3.0	2.0	1.0	1.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
466	3.0	2.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
467	3.0	2.0	1.0	1.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
468	3.0	2.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
469	3.0	2.0	1.0	1.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
470	3.0	2.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
471	3.0	2.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
472	3.0	2.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
473	3.0	2.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
474	3.0	2.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
475	3.0	2.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
476	3.0	2.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
477	3.0	2.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
478	3.0	2.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
479	3.0	2.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
480	3.0	2.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
481	3.0	2.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
482	3.0	2.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
483	3.0	2.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
484	3.0	2.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
485	3.0	2.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
486	3.0	2.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
487	3.0	2.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
488	3.0	2.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
489	3.0	2.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
490	3.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
491	3.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
492	3.0	2.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
493	3.0	2.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
494	3.0	2.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
495	3.0	2.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
496	3.0	2.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
497	3.0	2.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
498	3.0	2.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
499	3.0	2.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
500	3.0	2.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
501	3.0	2.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
502	3.0	2.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
503	3.0	2.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
504	3.0	2.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
505	3.0	2.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
506	3.0	2.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
507	3.0	2.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
508	3.0	2.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
509	3.0	2.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
510	3.0	2.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
511	3.0	2.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
512	3.0	2.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
513	3.0	2.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
514	3.0	2.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
515	3.0	2.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
516	3.0	2.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
517	3.0	2.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
518	3.0	2.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
519	3.0	2.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
520	3.0	3.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
521	3.0	3.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
522	3.0	3.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
523	3.0	3.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
524	3.0	3.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
525	3.0	3.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
526	3.0	3.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
527	3.0	3.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
528	3.0	3.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
529	3.0	3.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
530	3.0	3.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
531	3.0	3.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
532	3.0	3.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
533	3.0	3.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
534	3.0	3.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
535	3.0	3.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
536	3.0	3.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
537	3.0	3.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
538	3.0	3.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
539	3.0	3.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
540	3.0	3.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
541	3.0	3.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
542	3.0	3.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
543	3.0	3.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
544	3.0	3.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
545	3.0	3.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
546	3.0	3.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
547	3.0	3.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
548	3.0	3.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
549	3.0	3.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
550	3.0	3.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
551	3.0	3.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
552	3.0	3.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
553	3.0	3.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
554	3.0	3.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
555	3.0	3.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
556	3.0	3.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
557	3.0	3.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
558	3.0	3.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
559	3.0	3.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
560	3.0	4.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	3.0
561	3.0	4.0	2.0	2.0	1.0	1.0	1.0	.0	.0	.0	2.0	4.0
562	3.0	4.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	3.0
563	3.0	4.0	2.0	2.0	1.0	1.0	2.0	.0	.0	.0	2.0	4.0
564	3.0	4.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	3.0
565	3.0	4.0	2.0	2.0	1.0	1.0	3.0	2.0	.0	.0	.0	4.0
566	3.0	4.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	3.0
567	3.0	4.0	2.0	2.0	1.0	1.0	4.0	.0	2.0	.0	.0	4.0
568	3.0	4.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	3.0
569	3.0	4.0	2.0	2.0	1.0	1.0	5.0	.0	.0	2.0	.0	4.0
570	3.0	4.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
571	3.0	4.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
572	3.0	4.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
573	3.0	4.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
574	3.0	4.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
575	3.0	4.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
576	3.0	4.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
577	3.0	4.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
578	3.0	4.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
579	3.0	4.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
580	3.0	4.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	3.0
581	3.0	4.0	2.0	2.0	2.0	1.0	1.0	.0	.0	.0	2.0	4.0
582	3.0	4.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	3.0
583	3.0	4.0	2.0	2.0	2.0	1.0	2.0	.0	.0	.0	2.0	4.0
584	3.0	4.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	3.0
585	3.0	4.0	2.0	2.0	2.0	1.0	3.0	2.0	.0	.0	.0	4.0
586	3.0	4.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	3.0
587	3.0	4.0	2.0	2.0	2.0	1.0	4.0	.0	2.0	.0	.0	4.0
588	3.0	4.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	3.0
589	3.0	4.0	2.0	2.0	2.0	1.0	5.0	.0	.0	2.0	.0	4.0
590	3.0	4.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
591	3.0	4.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
592	3.0	4.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
593	3.0	4.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
594	3.0	4.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
595	3.0	4.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
596	3.0	4.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
597	3.0	4.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
598	3.0	4.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
599	3.0	4.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0

SHIP NUM	PROF PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
600	5.0	.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
601	5.0	.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
602	5.0	.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
603	5.0	.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
604	5.0	.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
605	5.0	.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
606	5.0	.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
607	5.0	.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
608	5.0	.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
609	5.0	.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
610	5.0	.0	2.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
611	5.0	.0	2.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
612	5.0	.0	2.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
613	5.0	.0	2.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
614	5.0	.0	2.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
615	5.0	.0	2.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
616	5.0	.0	2.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
617	5.0	.0	2.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
618	5.0	.0	2.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
619	5.0	.0	2.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
620	5.0	.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
621	5.0	.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
622	5.0	.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
623	5.0	.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
624	5.0	.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
625	5.0	.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
626	5.0	.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
627	5.0	.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
628	5.0	.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
629	5.0	.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
630	5.0	.0	3.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
631	5.0	.0	3.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
632	5.0	.0	3.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
633	5.0	.0	3.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
634	5.0	.0	3.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
635	5.0	.0	3.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
636	5.0	.0	3.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
637	5.0	.0	3.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
638	5.0	.0	3.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
639	5.0	.0	3.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
640	5.0	.0	4.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
641	5.0	.0	4.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
642	5.0	.0	4.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
643	5.0	.0	4.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
644	5.0	.0	4.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
645	5.0	.0	4.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
646	5.0	.0	4.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
647	5.0	.0	4.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
648	5.0	.0	4.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
649	5.0	.0	4.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
650	6.0	.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
651	6.0	.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
652	6.0	.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
653	6.0	.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
654	6.0	.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
655	6.0	.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
656	6.0	.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
657	6.0	.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
658	6.0	.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
659	6.0	.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
660	6.0	.0	2.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
661	6.0	.0	2.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
662	6.0	.0	2.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
663	6.0	.0	2.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
664	6.0	.0	2.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
665	6.0	.0	2.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
666	6.0	.0	2.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
667	6.0	.0	2.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
668	6.0	.0	2.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
669	6.0	.0	2.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
670	6.0	.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
671	6.0	.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
672	6.0	.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
673	6.0	.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
674	6.0	.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
675	6.0	.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
676	6.0	.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
677	6.0	.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
678	6.0	.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
679	6.0	.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
680	6.0	.0	3.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
681	6.0	.0	3.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
682	6.0	.0	3.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
683	6.0	.0	3.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
684	6.0	.0	3.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
685	6.0	.0	3.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
686	6.0	.0	3.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
687	6.0	.0	3.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
688	6.0	.0	3.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
689	6.0	.0	3.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
690	6.0	.0	4.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
691	6.0	.0	4.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
692	6.0	.0	4.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
693	6.0	.0	4.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
694	6.0	.0	4.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
695	6.0	.0	4.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
696	6.0	.0	4.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
697	6.0	.0	4.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
698	6.0	.0	4.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
699	6.0	.0	4.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
700	7.0	.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
701	7.0	.0	1.0	1.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
702	7.0	.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
703	7.0	.0	1.0	1.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
704	7.0	.0	1.0	1.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
705	7.0	.0	1.0	1.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
706	7.0	.0	1.0	1.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
707	7.0	.0	1.0	1.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
708	7.0	.0	1.0	1.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
709	7.0	.0	1.0	1.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
710	7.0	.0	2.0	1.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
711	7.0	.0	2.0	1.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
712	7.0	.0	2.0	1.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
713	7.0	.0	2.0	1.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
714	7.0	.0	2.0	1.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
715	7.0	.0	2.0	1.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
716	7.0	.0	2.0	1.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
717	7.0	.0	2.0	1.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
718	7.0	.0	2.0	1.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
719	7.0	.0	2.0	1.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
720	7.0	.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
721	7.0	.0	2.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
722	7.0	.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
723	7.0	.0	2.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
724	7.0	.0	2.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
725	7.0	.0	2.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
726	7.0	.0	2.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
727	7.0	.0	2.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
728	7.0	.0	2.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
729	7.0	.0	2.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
730	7.0	.0	3.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
731	7.0	.0	3.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
732	7.0	.0	3.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
733	7.0	.0	3.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
734	7.0	.0	3.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
735	7.0	.0	3.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
736	7.0	.0	3.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
737	7.0	.0	3.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
738	7.0	.0	3.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
739	7.0	.0	3.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0
740	7.0	.0	4.0	2.0	1.0	2.0	.0	.0	.0	.0	3.0	.0
741	7.0	.0	4.0	2.0	1.0	2.0	.0	.0	.0	.0	4.0	.0
742	7.0	.0	4.0	2.0	1.0	3.0	.0	.0	.0	.0	3.0	.0
743	7.0	.0	4.0	2.0	1.0	3.0	.0	.0	.0	.0	4.0	.0
744	7.0	.0	4.0	2.0	1.0	4.0	.0	3.0	.0	.0	.0	.0
745	7.0	.0	4.0	2.0	1.0	4.0	.0	4.0	.0	.0	.0	.0
746	7.0	.0	4.0	2.0	1.0	5.0	.0	.0	3.0	.0	.0	.0
747	7.0	.0	4.0	2.0	1.0	5.0	.0	.0	4.0	.0	.0	.0
748	7.0	.0	4.0	2.0	1.0	6.0	.0	.0	.0	3.0	.0	.0
749	7.0	.0	4.0	2.0	1.0	6.0	.0	.0	.0	4.0	.0	.0

SHIP NUM	PROP PLT	NB	NE	NSHFT	PRP TYP	SSE TYP	EME TYP	NU LSD	NU MSD	NU HSD	NU GTG	NU STG
750	7.0	.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
751	7.0	.0	1.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
752	7.0	.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
753	7.0	.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
754	7.0	.0	1.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
755	7.0	.0	1.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
756	7.0	.0	1.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
757	7.0	.0	1.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
758	7.0	.0	1.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
759	7.0	.0	1.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
760	7.0	.0	2.0	1.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
761	7.0	.0	2.0	1.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
762	7.0	.0	2.0	1.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
763	7.0	.0	2.0	1.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
764	7.0	.0	2.0	1.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
765	7.0	.0	2.0	1.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
766	7.0	.0	2.0	1.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
767	7.0	.0	2.0	1.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
768	7.0	.0	2.0	1.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
769	7.0	.0	2.0	1.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
770	7.0	.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
771	7.0	.0	2.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
772	7.0	.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
773	7.0	.0	2.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
774	7.0	.0	2.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
775	7.0	.0	2.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
776	7.0	.0	2.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
777	7.0	.0	2.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
778	7.0	.0	2.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
779	7.0	.0	2.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
780	7.0	.0	3.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
781	7.0	.0	3.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
782	7.0	.0	3.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
783	7.0	.0	3.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
784	7.0	.0	3.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
785	7.0	.0	3.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
786	7.0	.0	3.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
787	7.0	.0	3.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
788	7.0	.0	3.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
789	7.0	.0	3.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0
790	7.0	.0	4.0	2.0	2.0	2.0	.0	.0	.0	.0	3.0	.0
791	7.0	.0	4.0	2.0	2.0	2.0	.0	.0	.0	.0	4.0	.0
792	7.0	.0	4.0	2.0	2.0	3.0	.0	.0	.0	.0	3.0	.0
793	7.0	.0	4.0	2.0	2.0	3.0	.0	.0	.0	.0	4.0	.0
794	7.0	.0	4.0	2.0	2.0	4.0	.0	3.0	.0	.0	.0	.0
795	7.0	.0	4.0	2.0	2.0	4.0	.0	4.0	.0	.0	.0	.0
796	7.0	.0	4.0	2.0	2.0	5.0	.0	.0	3.0	.0	.0	.0
797	7.0	.0	4.0	2.0	2.0	5.0	.0	.0	4.0	.0	.0	.0
798	7.0	.0	4.0	2.0	2.0	6.0	.0	.0	.0	3.0	.0	.0
799	7.0	.0	4.0	2.0	2.0	6.0	.0	.0	.0	4.0	.0	.0

APPENDIX II

LIST OF ATTRIBUTES GENERATED FOR THE CASE STUDY

LIST OF ABBREVIATIONS USED IN APPENDIX II

SHIP NUM	– Ship Reference Number
VS	– Maximum Sustained Speed
DIS	– Full Load Displacement
INTVOL	– Total Internal Volume
WTG2/SHP	– Weight of Propulsion Plant / Shaft Horsepower
WTG3/KW	– Weight of Electrical Plant / Kilo-Watt of Power
WTG2+WTG3	– Weight of Propulsion Plant + Weight of Electrical Plant

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
1	28.15	4186.77	482785.30	31.67	79.12	728.00	390.99
2	28.15	4186.77	482785.30	31.67	79.12	728.00	390.99
3	28.11	4206.76	485694.10	31.68	75.92	735.13	394.33
4	28.13	4197.52	482918.10	31.67	82.17	734.27	393.40
5	28.09	4217.51	485827.30	31.68	78.73	741.41	396.73
6	28.19	4164.50	482510.60	31.67	72.79	714.99	386.00
7	28.15	4184.47	485418.70	31.68	70.10	722.12	389.34
8	28.23	4147.71	482304.00	31.67	68.01	705.17	382.24
9	28.19	4167.67	485211.60	31.68	65.71	712.31	385.57
10	28.81	3867.64	466273.60	31.64	79.59	692.91	371.67
11	28.71	3910.98	469439.20	31.65	82.88	713.16	380.03
12	28.81	3867.64	466273.60	31.64	79.59	692.91	371.67
13	28.71	3910.98	469439.20	31.65	82.88	713.16	380.03
14	28.48	4022.09	468153.10	31.65	135.51	782.90	406.21
15	28.39	4063.88	471298.10	31.65	132.82	802.44	414.29
16	28.72	3905.94	466741.50	31.64	93.39	715.12	380.20
17	28.66	3934.64	469729.10	31.65	90.55	726.88	385.30
18	28.86	3843.06	465974.30	31.64	70.72	678.65	366.19
19	28.81	3865.07	468878.30	31.65	67.98	686.54	369.80
20	28.25	4135.71	482185.80	29.98	79.06	697.62	382.21
21	28.21	4155.93	485092.50	29.98	75.86	704.75	385.53
22	28.25	4135.71	482185.80	29.98	79.06	697.62	382.21
23	28.21	4155.93	485092.50	29.98	75.86	704.75	385.53
24	28.23	4146.44	482317.30	29.98	82.11	703.90	384.62
25	28.19	4166.66	485224.40	29.98	78.67	711.03	387.94
26	28.29	4113.47	481913.60	29.97	72.73	684.61	377.22
27	28.25	4133.69	484819.80	29.98	70.04	691.74	380.54
28	28.33	4096.70	481709.00	29.97	67.95	674.80	373.46
29	28.28	4116.93	484614.70	29.98	65.65	681.93	376.78
30	28.92	3815.87	465668.70	29.95	79.51	662.54	362.84
31	28.82	3859.17	468830.30	29.96	82.81	682.78	371.21
32	28.92	3815.87	465668.70	29.95	79.51	662.54	362.84
33	28.82	3859.17	468830.30	29.96	82.81	682.78	371.21
34	28.58	3970.97	467562.40	29.95	135.44	752.52	397.42
35	28.49	4012.99	470712.80	29.96	132.75	772.07	405.51
36	28.84	3854.11	466132.80	29.95	93.31	684.74	371.38
37	28.77	3882.79	469117.90	29.96	90.48	696.50	376.48
38	28.98	3791.33	465371.90	29.95	70.64	648.28	357.36
39	28.93	3813.32	468274.10	29.95	67.91	656.16	360.98
40	28.17	4185.48	482760.00	31.67	79.11	728.02	390.87
41	28.13	4205.81	485659.90	31.68	75.92	735.15	394.18
42	28.17	4185.48	482760.00	31.67	79.11	728.02	390.87
43	28.13	4205.81	485659.90	31.68	75.92	735.15	394.18
44	28.15	4196.35	482897.60	31.67	82.17	734.29	393.28
45	28.11	4216.68	485797.70	31.68	78.72	741.42	396.59
46	28.21	4162.95	482475.30	31.67	72.78	715.00	385.86
47	28.17	4183.28	485374.70	31.68	70.09	722.13	389.17
48	28.25	4145.96	482261.10	31.67	68.01	705.19	382.09
49	28.21	4166.28	485159.90	31.68	65.70	712.32	385.40
50	28.82	3866.89	466250.80	31.64	79.58	692.93	371.54

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
51	28.73	3909.56	469394.90	31.65	82.87	713.17	379.87
52	28.82	3866.89	466250.80	31.64	79.58	692.93	371.54
53	28.73	3909.56	469394.90	31.65	82.87	713.17	379.87
54	28.49	4020.88	468125.00	31.65	135.51	782.91	406.08
55	28.41	4062.88	471279.60	31.66	132.82	802.46	414.16
56	28.74	3904.64	466701.90	31.64	93.38	715.13	380.05
57	28.68	3933.03	469680.30	31.65	90.54	726.88	385.14
58	28.88	3842.67	465962.50	31.64	70.72	678.67	366.07
59	28.83	3864.22	468851.10	31.65	67.98	686.55	369.66
60	28.27	4133.94	482142.20	29.98	79.05	697.63	382.06
61	28.23	4154.25	485040.40	29.98	75.86	704.76	385.37
62	28.27	4133.94	482142.20	29.98	79.05	697.63	382.06
63	28.23	4154.25	485040.40	29.98	75.86	704.76	385.37
64	28.25	4144.80	482278.80	29.98	82.10	703.91	384.47
65	28.21	4165.11	485177.10	29.98	78.67	711.04	387.78
66	28.31	4111.45	481859.80	29.98	72.72	684.62	377.06
67	28.27	4131.75	484757.30	29.98	70.04	691.75	380.36
68	28.35	4094.48	481647.10	29.97	67.95	674.80	373.28
69	28.31	4114.78	484544.30	29.98	65.64	681.93	376.59
70	28.93	3816.40	465684.70	29.95	79.51	662.56	362.76
71	28.84	3859.04	468826.10	29.96	82.81	682.80	371.10
72	28.93	3816.40	465684.70	29.95	79.51	662.56	362.76
73	28.84	3859.04	468826.10	29.96	82.81	682.80	371.10
74	28.60	3969.66	467525.40	29.95	135.43	752.53	397.28
75	28.51	4011.61	470676.30	29.96	132.75	772.08	405.36
76	28.85	3854.06	466131.30	29.95	93.31	684.76	371.28
77	28.79	3882.33	469103.70	29.96	90.48	696.51	376.36
78	28.99	3791.90	465388.50	29.95	70.65	648.30	357.29
79	28.94	3813.81	468288.40	29.95	67.92	656.18	360.89
80	28.00	4275.97	482622.90	34.94	79.10	786.34	407.46
81	27.97	4296.03	485535.90	34.95	75.90	793.48	410.79
82	28.00	4275.97	482622.90	34.94	79.10	786.34	407.46
83	27.97	4296.03	485535.90	34.95	75.90	793.48	410.79
84	27.98	4287.07	482768.50	34.94	82.15	792.62	409.88
85	27.95	4307.11	485681.00	34.95	78.71	799.76	413.21
86	28.04	4253.03	482324.50	34.94	72.77	773.32	402.45
87	28.00	4277.21	485412.40	34.95	70.10	780.54	405.88
88	28.07	4239.75	482291.30	34.94	68.01	763.59	398.80
89	28.03	4260.16	485194.10	34.95	65.70	770.72	402.11
90	28.63	3958.49	466183.60	34.91	79.57	751.30	388.17
91	28.54	4001.43	469340.40	34.92	82.87	771.55	396.52
92	28.63	3958.49	466183.60	34.91	79.57	751.30	388.17
93	28.54	4001.43	469340.40	34.92	82.87	771.55	396.52
94	28.32	4111.09	467852.30	34.91	135.48	841.19	422.52
95	28.24	4153.17	471032.00	34.92	132.79	860.75	430.63
96	28.55	3996.40	466643.30	34.91	93.38	773.51	396.69
97	28.49	4024.93	469628.40	34.92	90.54	785.26	401.78
98	28.68	3934.16	465889.60	34.91	70.71	737.04	382.70
99	28.63	3955.97	468789.10	34.92	67.97	744.93	386.30
100	27.99	4281.37	482691.20	35.11	79.11	789.47	408.37

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
101	27.96	4301.44	485604.60	35.12	75.91	796.61	411.70
102	27.99	4281.37	482691.20	35.11	79.11	789.47	408.37
103	27.96	4301.44	485604.60	35.12	75.91	796.61	411.70
104	27.97	4292.48	482837.20	35.11	82.16	795.75	410.79
105	27.94	4312.52	485749.80	35.12	78.72	802.88	414.12
106	28.03	4258.44	482392.60	35.11	72.78	776.45	403.36
107	27.99	4282.54	485477.60	35.12	70.10	783.66	406.79
108	28.06	4245.08	482355.90	35.11	68.02	766.71	399.70
109	28.02	4265.48	485259.10	35.12	65.71	773.85	403.01
110	28.62	3963.72	466243.70	35.09	79.58	754.42	389.07
111	28.53	4006.66	469400.90	35.09	82.87	774.67	397.42
112	28.62	3963.72	466243.70	35.09	79.58	754.42	389.07
113	28.53	4006.66	469400.90	35.09	82.87	774.67	397.42
114	28.31	4116.48	467919.30	35.09	135.48	844.31	423.43
115	28.22	4159.94	471146.40	35.10	132.80	863.88	431.60
116	28.54	4001.64	466703.90	35.09	93.38	776.63	397.59
117	28.48	4030.22	469690.90	35.10	90.54	788.39	402.68
118	28.67	3939.38	465949.30	35.08	70.72	740.16	383.60
119	28.62	3961.20	468849.20	35.09	67.98	748.05	387.20
120	28.00	4275.97	482622.90	34.94	79.10	786.34	407.46
121	27.97	4296.03	485535.90	34.95	75.90	793.48	410.79
122	28.00	4275.97	482622.90	34.94	79.10	786.34	407.46
123	27.97	4296.03	485535.90	34.95	75.90	793.48	410.79
124	27.98	4287.07	482768.50	34.94	82.15	792.62	409.88
125	27.95	4307.11	485681.00	34.95	78.71	799.76	413.21
126	28.04	4253.03	482324.50	34.94	72.77	773.32	402.45
127	28.00	4277.21	485412.40	34.95	70.10	780.54	405.88
128	28.07	4239.75	482291.30	34.94	68.01	763.59	398.80
129	28.03	4260.16	485194.10	34.95	65.70	770.72	402.11
130	28.63	3958.49	466183.60	34.91	79.57	751.30	388.17
131	28.54	4001.43	469340.40	34.92	82.87	771.55	396.52
132	28.63	3958.49	466183.60	34.91	79.57	751.30	388.17
133	28.54	4001.43	469340.40	34.92	82.87	771.55	396.52
134	28.32	4111.09	467852.30	34.91	135.48	841.19	422.52
135	28.24	4153.17	471032.00	34.92	132.79	860.75	430.63
136	28.55	3996.40	466643.30	34.91	93.38	773.51	396.69
137	28.49	4024.93	469628.40	34.92	90.54	785.26	401.78
138	28.68	3934.16	465889.60	34.91	70.71	737.04	382.70
139	28.63	3955.97	468789.10	34.92	67.97	744.93	386.30
140	27.99	4281.37	482691.20	35.11	79.11	789.47	408.37
141	27.96	4301.44	485604.60	35.12	75.91	796.61	411.70
142	27.99	4281.37	482691.20	35.11	79.11	789.47	408.37
143	27.96	4301.44	485604.60	35.12	75.91	796.61	411.70
144	27.97	4292.48	482837.20	35.11	82.16	795.75	410.79
145	27.94	4312.52	485749.80	35.12	78.72	802.88	414.12
146	28.03	4258.44	482392.60	35.11	72.78	776.45	403.36
147	27.99	4282.54	485477.60	35.12	70.10	783.66	406.79
148	28.06	4245.08	482355.90	35.11	68.02	766.71	399.70
149	28.02	4265.48	485259.10	35.12	65.71	773.85	403.01
150	28.62	3963.72	466243.70	35.09	79.58	754.42	389.07

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
151	28.53	4006.66	469400.90	35.09	82.87	774.67	397.42
152	28.62	3963.72	466243.70	35.09	79.58	754.42	389.07
153	28.53	4006.66	469400.90	35.09	82.87	774.67	397.42
154	28.31	4116.48	467919.30	35.09	135.48	844.31	423.43
155	28.22	4159.94	471146.40	35.10	132.80	863.88	431.60
156	28.54	4001.64	466703.90	35.09	93.38	776.63	397.59
157	28.48	4030.22	469690.90	35.10	90.54	788.39	402.68
158	28.67	3939.38	465949.30	35.08	70.72	740.16	383.60
159	28.62	3961.20	468849.20	35.09	67.98	748.05	387.20
160	28.00	4275.99	482623.90	34.94	79.10	786.34	407.46
161	27.97	4296.03	485535.90	34.95	75.90	793.48	410.79
162	28.00	4275.99	482623.90	34.94	79.10	786.34	407.46
163	27.97	4296.03	485535.90	34.95	75.90	793.48	410.79
164	27.98	4287.07	482768.50	34.94	82.15	792.62	409.88
165	27.95	4307.11	485681.00	34.95	78.71	799.76	413.21
166	28.04	4253.03	482324.50	34.94	72.77	773.32	402.45
167	28.01	4273.06	485235.80	34.95	70.08	780.46	405.78
168	28.08	4235.71	482099.00	34.94	67.99	763.50	398.68
169	28.04	4255.74	485010.00	34.95	65.69	770.64	402.00
170	28.64	3959.30	466047.20	34.91	79.56	751.24	388.04
171	28.54	4001.78	469209.20	34.92	82.85	771.49	396.40
172	28.64	3959.30	466047.20	34.91	79.56	751.24	388.04
173	28.54	4001.78	469209.20	34.92	82.85	771.49	396.40
174	28.31	4112.70	467907.20	34.91	135.48	841.20	422.59
175	28.23	4154.54	471079.00	34.92	132.80	860.76	430.69
176	28.55	3997.89	466528.30	34.91	93.36	773.45	396.57
177	28.49	4025.62	469507.30	34.92	90.52	785.20	401.67
178	28.69	3934.53	465739.40	34.91	70.69	736.97	382.55
179	28.64	3955.51	468632.70	34.92	67.96	744.85	386.16
180	27.99	4281.40	482692.30	35.11	79.11	789.47	408.37
181	27.96	4301.44	485604.60	35.12	75.91	796.61	411.70
182	27.99	4281.40	482692.30	35.11	79.11	789.47	408.37
183	27.96	4301.44	485604.60	35.12	75.91	796.61	411.70
184	27.97	4292.48	482837.20	35.11	82.16	795.75	410.79
185	27.94	4312.52	485749.80	35.12	78.72	802.88	414.12
186	28.03	4258.44	482392.60	35.11	72.78	776.45	403.36
187	28.00	4278.47	485304.20	35.12	70.09	783.58	406.69
188	28.07	4241.12	482167.00	35.11	68.00	766.63	399.58
189	28.03	4261.15	485078.30	35.12	65.69	773.76	402.91
190	28.62	3964.57	466109.60	35.08	79.56	754.36	388.94
191	28.53	4007.05	469272.00	35.09	82.86	774.61	397.30
192	28.62	3964.57	466109.60	35.08	79.56	754.36	388.94
193	28.53	4007.05	469272.00	35.09	82.86	774.61	397.30
194	28.30	4118.09	467974.30	35.09	135.49	844.33	423.50
195	28.22	4159.94	471146.40	35.10	132.80	863.88	431.60
196	28.54	4003.17	466591.00	35.08	93.37	776.57	397.48
197	28.48	4030.90	469570.30	35.09	90.53	788.33	402.57
198	28.68	3939.80	465801.60	35.08	70.70	740.10	383.46
199	28.63	3960.78	468695.10	35.09	67.96	747.98	387.06
200	28.09	4216.24	482866.30	32.02	79.13	734.23	393.78

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
201	28.06	4236.66	485775.50	32.03	75.93	741.37	397.10
202	28.09	4216.24	482866.30	32.02	79.13	734.23	393.78
203	28.06	4236.66	485775.50	32.03	75.93	741.37	397.10
204	28.07	4226.99	482999.30	32.02	82.18	740.51	396.19
205	28.04	4247.40	485908.80	32.03	78.73	747.64	399.51
206	28.14	4193.96	482591.30	32.02	72.80	721.22	388.79
207	28.10	4214.38	485499.70	32.02	70.10	728.36	392.11
208	28.17	4177.16	482384.30	32.02	68.02	711.41	385.02
209	28.13	4197.58	485292.30	32.02	65.71	718.54	388.35
210	28.74	3896.64	466335.30	31.99	79.59	699.15	374.43
211	28.65	3939.98	469501.30	32.00	82.88	719.39	382.80
212	28.74	3896.64	466335.30	31.99	79.59	699.15	374.43
213	28.65	3939.98	469501.30	32.00	82.88	719.39	382.80
214	28.41	4051.39	468228.20	31.99	135.52	789.13	408.99
215	28.33	4093.18	471374.20	32.00	132.83	808.68	417.07
216	28.66	3934.92	466803.40	31.99	93.40	721.35	382.97
217	28.60	3963.63	469791.60	32.00	90.56	733.11	388.07
218	28.80	3872.07	466035.60	31.99	70.73	684.88	368.95
219	28.75	3894.09	468940.00	32.00	67.99	692.77	372.57
220	28.19	4165.09	482265.10	30.32	79.06	703.86	384.99
221	28.15	4185.66	485172.40	30.33	75.87	710.99	388.31
222	28.19	4165.09	482265.10	30.32	79.06	703.86	384.99
223	28.15	4185.66	485172.40	30.33	75.87	710.99	388.31
224	28.17	4175.82	482396.90	30.32	82.12	710.13	387.40
225	28.13	4196.40	485304.40	30.33	78.68	717.26	390.72
226	28.23	4142.85	481992.50	30.32	72.74	690.85	380.01
227	28.19	4163.41	484899.20	30.33	70.05	697.98	383.32
228	28.26	4126.08	481787.60	30.32	67.96	681.03	376.24
229	28.22	4146.64	484693.70	30.33	65.66	688.17	379.56
230	28.86	3844.88	465729.30	30.29	79.52	668.77	365.61
231	28.76	3888.18	468891.60	30.30	82.81	689.01	373.97
232	28.86	3844.88	465729.30	30.29	79.52	668.77	365.61
233	28.76	3888.18	468891.60	30.30	82.81	689.01	373.97
234	28.52	3999.93	467624.70	30.30	135.45	758.75	400.19
235	28.43	4042.11	470781.70	30.31	132.76	778.30	408.29
236	28.77	3883.11	466193.80	30.30	93.32	690.97	374.14
237	28.71	3911.80	469179.60	30.30	90.49	702.73	379.24
238	28.91	3820.34	465432.00	30.29	70.65	654.51	360.13
239	28.86	3842.34	468334.80	30.30	67.92	662.39	363.74
240	28.12	4209.47	482791.10	32.02	79.12	734.24	393.44
241	28.08	4229.80	485691.00	32.03	75.92	741.37	396.75
242	28.12	4209.47	482791.10	32.02	79.12	734.24	393.44
243	28.08	4229.80	485691.00	32.03	75.92	741.37	396.75
244	28.10	4220.34	482928.80	32.02	82.17	740.52	395.85
245	28.06	4240.67	485828.90	32.03	78.73	747.65	399.16
246	28.16	4186.96	482506.40	32.02	72.79	721.23	388.44
247	28.12	4207.28	485405.70	32.03	70.10	728.36	391.75
248	28.19	4169.98	482292.10	32.02	68.01	711.41	384.66
249	28.16	4190.30	485191.00	32.03	65.70	718.54	387.97
250	28.77	3890.39	466257.70	31.99	79.58	699.15	374.09

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
251	28.67	3933.19	469407.70	32.00	82.87	719.39	382.43
252	28.77	3890.39	466257.70	31.99	79.58	699.15	374.09
253	28.67	3933.19	469407.70	32.00	82.87	719.39	382.43
254	28.44	4044.47	468139.30	32.00	135.51	789.13	408.63
255	28.35	4086.46	471294.10	32.00	132.82	808.68	416.72
256	28.69	3928.16	466710.80	31.99	93.38	721.35	382.60
257	28.62	3956.71	469695.20	32.00	90.55	733.10	387.70
258	28.82	3866.17	465969.30	31.99	70.72	684.89	368.62
259	28.77	3887.88	468863.80	32.00	67.98	692.77	372.22
260	28.22	4157.96	482172.60	30.32	79.06	703.86	384.63
261	28.18	4178.26	485070.80	30.33	75.86	710.99	387.94
262	28.22	4157.96	482172.60	30.32	79.06	703.86	384.63
263	28.18	4178.26	485070.80	30.33	75.86	710.99	387.94
264	28.19	4168.80	482309.30	30.33	82.11	710.13	387.05
265	28.16	4189.11	485207.70	30.33	78.67	717.26	390:35
266	28.26	4135.47	481890.20	30.32	72.73	690.84	379.63
267	28.22	4155.77	484787.70	30.33	70.04	697.97	382.94
268	28.29	4118.52	481677.50	30.32	67.95	681.03	375.86
269	28.25	4138.81	484574.70	30.33	65.65	688.16	379.17
270	28.87	3839.24	465669.30	30.30	79.51	668.77	365.30
271	28.78	3882.55	468833.20	30.30	82.81	689.02	373.65
272	28.87	3839.24	465669.30	30.30	79.51	668.77	365.30
273	28.78	3882.55	468833.20	30.30	82.81	689.02	373.65
274	28.54	3993.27	467539.00	30.30	135.43	758.75	399.83
275	28.46	4035.20	470690.10	30.31	132.75	778.30	407.92
276	28.79	3877.55	466137.60	30.30	93.31	690.98	373.83
277	28.73	3905.82	469110.40	30.31	90.48	702.73	378.91
278	28.91	3813.06	465359.80	30.29	70.64	654.50	359.85
279	28.87	3835.17	468265.90	30.30	67.91	662.39	363.45
280	27.98	4288.12	482494.00	35.29	79.09	792.53	409.54
281	27.95	4308.11	485404.80	35.29	75.89	799.66	412.87
282	27.98	4288.12	482494.00	35.29	79.09	792.53	409.54
283	27.95	4308.11	485404.80	35.29	75.89	799.66	412.87
284	27.96	4299.19	482638.80	35.29	82.14	798.80	411.96
285	27.93	4319.22	485551.10	35.29	78.70	805.94	415.29
286	28.02	4264.90	482185.50	35.29	72.76	779.50	404.52
287	27.98	4285.19	485105.80	35.29	70.07	786.64	407.86
288	28.04	4251.31	482162.30	35.29	68.00	769.77	400.88
289	28.00	4271.94	485073.30	35.30	65.69	776.91	404.20
290	28.60	3969.96	466049.50	35.26	79.56	757.49	390.25
291	28.51	4012.88	469205.60	35.27	82.85	777.73	398.59
292	28.60	3969.96	466049.50	35.26	79.56	757.49	390.25
293	28.51	4012.88	469205.60	35.27	82.85	777.73	398.59
294	28.29	4124.93	467778.70	35.26	135.47	847.39	424.67
295	28.20	4166.74	470950.10	35.27	132.78	866.94	432.77
296	28.52	4007.84	466508.60	35.26	93.36	779.69	398.76
297	28.46	4036.44	469496.40	35.27	90.52	791.45	403.86
298	28.65	3945.66	465756.10	35.26	70.69	743.23	384.78
299	28.61	3967.47	468655.50	35.27	67.96	751.11	388.38
300	27.97	4293.53	482562.60	35.46	79.09	795.65	410.45

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
301	27.94	4313.51	485473.30	35.47	75.90	802.79	413.78
302	27.97	4293.53	482562.60	35.46	79.09	795.65	410.45
303	27.94	4313.51	485473.30	35.47	75.90	802.79	413.78
304	27.95	4304.60	482707.40	35.46	82.15	801.93	412.87
305	27.92	4324.63	485619.90	35.47	78.71	809.06	416.20
306	28.01	4270.30	482253.60	35.46	72.76	782.63	405.43
307	27.97	4290.59	485174.40	35.47	70.07	789.77	408.77
308	28.04	4253.06	482030.40	35.46	67.99	772.81	401.65
309	27.99	4277.26	485138.40	35.47	65.70	780.03	405.11
310	28.59	3975.19	466109.50	35.43	79.56	760.61	391.15
311	28.50	4018.13	469266.60	35.44	82.86	780.85	399.50
312	28.59	3975.19	466109.50	35.43	79.56	760.61	391.15
313	28.50	4018.13	469266.60	35.44	82.86	780.85	399.50
314	28.28	4130.32	467845.80	35.44	135.47	850.51	425.58
315	28.19	4172.13	471017.40	35.44	132.79	870.07	433.68
316	28.51	4013.08	466569.20	35.43	93.37	782.81	399.67
317	28.45	4041.72	469558.70	35.44	90.53	794.57	404.76
318	28.64	3950.88	465815.80	35.43	70.70	746.35	385.68
319	28.60	3972.69	468715.40	35.44	67.96	754.23	389.28
320	28.00	4275.53	482326.70	35.29	79.07	792.48	409.05
321	27.97	4295.87	485249.00	35.29	75.88	799.62	412.39
322	28.00	4275.53	482326.70	35.29	79.07	792.48	409.05
323	27.97	4295.87	485249.00	35.29	75.88	799.62	412.39
324	27.98	4286.93	482482.50	35.29	82.13	798.76	411.48
325	27.95	4306.90	485392.40	35.29	78.69	805.90	414.80
326	28.04	4252.67	482030.80	35.28	72.74	779.46	404.04
327	27.99	4276.91	485143.00	35.30	70.07	786.69	407.50
328	28.06	4239.28	482015.70	35.29	67.99	769.74	400.41
329	28.03	4259.88	484925.60	35.29	65.68	776.87	403.73
330	28.63	3958.13	465913.00	35.26	79.54	757.45	389.78
331	28.54	4001.03	469068.10	35.27	82.83	777.70	398.12
332	28.63	3958.13	465913.00	35.26	79.54	757.45	389.78
333	28.54	4001.03	469068.10	35.27	82.83	777.70	398.12
334	28.32	4110.78	467559.90	35.26	135.44	847.33	424.11
335	28.23	4154.52	470796.40	35.27	132.76	866.90	432.29
336	28.55	3995.99	466371.00	35.26	93.34	779.66	398.30
337	28.49	4024.49	469354.60	35.27	90.51	791.41	403.39
338	28.68	3933.84	465620.30	35.26	70.68	743.19	384.31
339	28.63	3955.64	468519.10	35.27	67.94	751.07	387.91
340	27.99	4281.27	482406.40	35.46	79.08	795.61	409.97
341	27.96	4301.27	485317.40	35.47	75.88	802.74	413.30
342	27.99	4281.27	482406.40	35.46	79.08	795.61	409.97
343	27.96	4301.27	485317.40	35.47	75.88	802.74	413.30
344	27.97	4292.34	482551.00	35.46	82.13	801.89	412.39
345	27.94	4312.30	485460.90	35.47	78.69	809.02	415.71
346	28.03	4258.07	482098.70	35.46	72.75	782.59	404.95
347	27.98	4282.23	485208.00	35.47	70.08	789.81	408.41
348	28.06	4244.59	482080.10	35.46	67.99	772.86	401.31
349	28.02	4265.20	484990.30	35.47	65.68	779.99	404.63
350	28.62	3963.35	465972.90	35.43	79.55	760.57	390.68

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
351	28.53	4006.26	469128.40	35.44	82.84	780.82	399.03
352	28.62	3963.35	465972.90	35.43	79.55	760.57	390.68
353	28.53	4006.26	469128.40	35.44	82.84	780.82	399.03
354	28.31	4116.16	467626.70	35.44	135.45	850.45	425.01
355	28.22	4159.91	470863.80	35.44	132.77	870.03	433.20
356	28.54	4001.22	466431.40	35.43	93.35	782.78	399.20
357	28.48	4029.76	469416.80	35.44	90.51	794.53	404.29
358	28.67	3939.05	465679.80	35.43	70.68	746.31	385.21
359	28.62	3960.86	468578.90	35.44	67.95	754.20	388.81
360	28.02	4263.62	482182.50	35.29	79.06	792.44	408.58
361	27.98	4283.63	485093.50	35.29	75.86	799.58	411.91
362	28.02	4263.62	482182.50	35.29	79.06	792.44	408.58
363	27.98	4283.63	485093.50	35.29	75.86	799.58	411.91
364	28.00	4274.68	482326.70	35.29	82.11	798.72	411.00
365	27.97	4294.70	485238.10	35.29	78.67	805.86	414.32
366	28.06	4240.68	481884.10	35.28	72.73	779.42	403.57
367	28.03	4260.69	484794.60	35.29	70.04	786.56	406.90
368	28.10	4223.38	481659.50	35.28	67.95	769.60	399.80
369	28.06	4243.39	484569.70	35.29	65.65	776.74	403.12
370	28.66	3948.05	465646.60	35.26	79.51	757.35	389.18
371	28.57	3990.46	468806.00	35.27	82.80	777.60	397.53
372	28.66	3948.05	465646.60	35.26	79.51	757.35	389.18
373	28.57	3990.46	468806.00	35.27	82.80	777.60	397.53
374	28.34	4100.49	467473.00	35.26	135.43	847.30	423.72
375	28.25	4142.29	470643.00	35.27	132.74	866.86	431.82
376	28.57	3986.58	466125.20	35.26	93.31	779.57	397.71
377	28.52	4014.26	469102.60	35.27	90.48	791.32	402.81
378	28.71	3923.32	465340.40	35.26	70.64	743.09	383.69
379	28.66	3944.27	468232.40	35.26	67.91	750.97	387.30
380	28.01	4269.02	482250.80	35.46	79.06	795.57	409.49
381	27.98	4289.03	485161.90	35.47	75.87	802.70	412.82
382	28.01	4269.02	482250.80	35.46	79.06	795.57	409.49
383	27.98	4289.03	485161.90	35.47	75.87	802.70	412.82
384	27.99	4280.08	482394.90	35.46	82.12	801.85	411.91
385	27.96	4300.10	485306.70	35.47	78.68	808.98	415.23
386	28.05	4246.08	481952.20	35.46	72.73	782.55	404.48
387	28.02	4266.09	484862.80	35.47	70.05	789.68	407.81
388	28.09	4228.77	481727.30	35.46	67.96	772.73	400.70
389	28.05	4248.79	484637.60	35.47	65.65	779.86	404.03
390	28.65	3953.31	465708.70	35.43	79.51	760.48	390.08
391	28.55	3995.73	468868.40	35.44	82.81	780.72	398.44
392	28.65	3953.31	465708.70	35.43	79.51	760.48	390.08
393	28.55	3995.73	468868.40	35.44	82.81	780.72	398.44
394	28.33	4105.88	467539.90	35.43	135.43	850.43	424.62
395	28.24	4147.68	470710.20	35.44	132.75	869.99	432.72
396	28.56	3991.84	466187.50	35.43	93.32	782.69	398.62
397	28.50	4019.53	469165.20	35.44	90.48	794.44	403.71
398	28.70	3928.58	465402.20	35.43	70.65	746.21	384.60
399	28.65	3949.53	468294.40	35.44	67.92	754.09	388.20
400	28.35	4085.38	481243.10	27.99	78.96	662.04	373.16

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
401	28.31	4105.21	484143.80	28.00	75.78	669.17	376.44
402	28.35	4085.38	481243.10	27.99	78.96	662.04	373.16
403	28.31	4105.21	484143.80	28.00	75.78	669.17	376.44
404	28.33	4096.09	481373.80	27.99	82.01	668.31	375.57
405	28.29	4115.92	484274.70	28.00	78.58	675.45	378.84
406	28.39	4063.17	480972.90	27.99	72.63	649.03	368.18
407	28.35	4083.00	483872.80	28.00	69.95	656.16	371.45
408	28.43	4046.42	480769.60	27.99	67.86	639.22	364.41
409	28.38	4066.26	483669.10	28.00	65.56	646.35	367.69
410	29.04	3766.17	464735.10	27.96	79.39	626.96	353.91
411	28.94	3809.01	467889.10	27.97	82.70	647.20	362.22
412	29.04	3766.17	464735.10	27.96	79.39	626.96	353.91
413	28.94	3809.01	467889.10	27.97	82.70	647.20	362.22
414	28.69	3921.11	466618.30	27.97	135.32	716.94	388.48
415	28.60	3962.84	469766.60	27.98	132.64	736.49	396.52
416	28.95	3804.37	465196.40	27.97	93.19	649.16	362.44
417	28.88	3832.62	468175.30	27.97	90.37	660.92	367.49
418	29.10	3741.58	464437.70	27.96	70.52	612.70	348.43
419	29.04	3763.18	467335.40	27.97	67.80	620.58	351.99
420	28.45	4034.48	480656.00	26.30	78.90	631.67	364.39
421	28.41	4054.59	483554.70	26.31	75.72	638.80	367.65
422	28.45	4034.48	480656.00	26.30	78.90	631.67	364.39
423	28.41	4054.59	483554.70	26.31	75.72	638.80	367.65
424	28.43	4045.17	480785.40	26.30	81.95	637.94	366.79
425	28.39	4065.28	483684.40	26.31	78.53	645.07	370.06
426	28.49	4012.31	480388.40	26.30	72.57	618.66	359.40
427	28.45	4032.41	483286.40	26.31	69.90	625.79	362.67
428	28.53	3995.61	480187.10	26.30	67.80	608.85	355.64
429	28.49	4015.70	483084.60	26.31	65.51	615.98	358.91
430	29.16	3714.45	464137.40	26.27	79.31	596.58	345.08
431	29.06	3757.29	467289.30	26.28	82.63	616.83	353.40
432	29.16	3714.45	464137.40	26.27	79.31	596.58	345.08
433	29.06	3757.29	467289.30	26.28	82.63	616.83	353.40
434	28.80	3869.31	466009.00	26.28	135.24	686.56	379.66
435	28.71	3910.99	469153.60	26.28	132.57	706.11	387.70
436	29.07	3752.62	464596.10	26.27	93.11	618.79	353.61
437	29.00	3781.04	467577.00	26.28	90.30	630.54	358.67
438	29.22	3689.11	463816.90	26.27	70.44	582.31	339.59
439	29.17	3711.27	466730.90	26.28	67.73	590.20	343.16
440	28.37	4083.12	481180.20	27.99	78.96	662.05	372.99
441	28.33	4103.00	484072.30	28.00	75.77	669.18	376.24
442	28.37	4083.12	481180.20	27.99	78.96	662.05	372.99
443	28.33	4103.00	484072.30	28.00	75.77	669.18	376.24
444	28.35	4093.96	481316.10	28.00	82.01	668.32	375.40
445	28.31	4113.85	484208.40	28.00	78.58	675.45	378.66
446	28.42	4060.64	480899.10	27.99	72.63	649.03	367.99
447	28.38	4080.51	483790.60	28.00	69.95	656.16	371.24
448	28.45	4043.69	480687.60	27.99	67.85	639.22	364.21
449	28.41	4063.56	483578.60	28.00	65.55	646.35	367.47
450	29.04	3766.79	464753.80	27.97	79.39	626.98	353.85

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
451	28.95	3809.68	467910.60	27.97	82.70	647.23	362.14
452	29.04	3766.79	464753.80	27.97	79.39	626.98	353.85
453	28.95	3809.68	467910.60	27.97	82.70	647.23	362.14
454	28.70	3920.19	466591.70	27.97	135.31	716.95	388.35
455	28.61	3961.68	469734.70	27.98	132.64	736.50	396.38
456	28.96	3805.13	465221.30	27.97	93.19	649.19	362.37
457	28.89	3832.95	468186.80	27.98	90.37	660.94	367.40
458	29.08	3740.49	464440.20	27.96	70.52	612.71	348.39
459	29.03	3762.06	467336.70	27.97	67.81	620.59	351.94
460	28.47	4031.77	480573.00	26.30	78.89	631.67	364.19
461	28.43	4051.63	483463.30	26.31	75.71	638.80	367.44
462	28.47	4031.77	480573.00	26.30	78.89	631.67	364.19
463	28.43	4051.63	483463.30	26.31	75.71	638.80	367.44
464	28.45	4042.60	480707.70	26.30	81.95	637.94	366.60
465	28.41	4062.46	483598.30	26.31	78.52	645.07	369.85
466	28.52	4009.32	480294.00	26.30	72.57	618.65	359.18
467	28.48	4029.18	483183.80	26.31	69.89	625.78	362.44
468	28.56	3992.40	480084.10	26.30	67.79	608.84	355.41
469	28.51	4012.25	482973.50	26.31	65.50	615.97	358.67
470	29.14	3712.38	464106.10	26.27	79.31	596.58	345.06
471	29.04	3755.42	467265.10	26.28	82.63	616.83	353.35
472	29.14	3712.38	464106.10	26.27	79.31	596.58	345.06
473	29.04	3755.42	467265.10	26.28	82.63	616.83	353.35
474	28.81	3869.61	466019.80	26.28	135.24	686.59	379.57
475	28.72	3910.71	469146.30	26.29	132.57	706.13	387.59
476	29.05	3750.82	464574.30	26.27	93.11	618.79	353.57
477	28.99	3779.98	467581.70	26.28	90.30	630.55	358.64
478	29.19	3687.39	463799.10	26.27	70.44	582.31	339.59
479	29.14	3709.17	466699.00	26.28	67.73	590.19	343.14
480	28.18	4177.66	481241.80	31.27	78.96	720.46	389.72
481	28.14	4197.61	484137.30	31.27	75.78	727.60	392.98
482	28.18	4177.66	481241.80	31.27	78.96	720.46	389.72
483	28.14	4197.61	484137.30	31.27	75.78	727.60	392.98
484	28.16	4188.49	481378.30	31.27	82.01	726.74	392.13
485	28.12	4208.49	484275.40	31.27	78.58	733.87	395.39
486	28.23	4155.12	480956.50	31.26	72.63	707.45	384.72
487	28.19	4175.06	483851.40	31.27	69.95	714.58	387.98
488	28.26	4138.12	480741.70	31.26	67.86	697.63	380.95
489	28.22	4158.06	483636.30	31.27	65.56	704.76	384.21
490	28.84	3859.63	464731.40	31.24	79.39	685.38	370.51
491	28.75	3902.01	467875.10	31.24	82.70	705.62	378.80
492	28.84	3859.63	464731.40	31.24	79.39	685.38	370.51
493	28.75	3902.01	467875.10	31.24	82.70	705.62	378.80
494	28.51	4012.85	466577.40	31.24	135.31	775.35	405.01
495	28.43	4054.48	469728.00	31.25	132.64	794.90	413.05
496	28.76	3897.38	465183.10	31.24	93.19	707.58	379.02
497	28.70	3925.35	468155.40	31.25	90.37	719.33	384.06
498	28.89	3835.40	464442.80	31.24	70.52	671.12	365.04
499	28.84	3856.75	467333.80	31.24	67.80	679.00	368.59
500	28.17	4182.96	481305.60	31.44	78.97	723.59	390.63

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
501	28.13	4202.92	484201.50	31.45	75.78	730.72	393.89
502	28.17	4182.96	481305.60	31.44	78.97	723.59	390.63
503	28.13	4202.92	484201.50	31.45	75.78	730.72	393.89
504	28.15	4193.79	481442.30	31.44	82.02	729.86	393.04
505	28.11	4213.80	484339.70	31.45	78.59	736.99	396.30
506	28.22	4160.42	481020.20	31.44	72.64	710.57	385.63
507	28.18	4180.37	483915.40	31.45	69.96	717.70	388.88
508	28.25	4143.42	480805.30	31.44	67.86	700.76	381.85
509	28.21	4163.37	483700.10	31.45	65.57	707.89	385.11
510	28.83	3864.83	464790.10	31.41	79.39	688.50	371.41
511	28.73	3907.22	467934.30	31.42	82.70	708.74	379.70
512	28.83	3864.83	464790.10	31.41	79.39	688.50	371.41
513	28.73	3907.22	467934.30	31.42	82.70	708.74	379.70
514	28.50	4018.11	466638.70	31.42	135.32	778.47	405.92
515	28.41	4059.76	469790.40	31.42	132.65	798.02	413.95
516	28.74	3902.59	465242.30	31.41	93.20	710.70	379.92
517	28.68	3930.57	468214.80	31.42	90.37	722.45	384.96
518	28.88	3840.60	464501.20	31.41	70.53	674.24	365.94
519	28.83	3861.95	467392.40	31.42	67.81	682.12	369.50
520	28.18	4177.66	481241.80	31.27	78.96	720.46	389.72
521	28.14	4197.61	484137.30	31.27	75.78	727.60	392.98
522	28.18	4177.66	481241.80	31.27	78.96	720.46	389.72
523	28.14	4197.61	484137.30	31.27	75.78	727.60	392.98
524	28.16	4188.49	481378.30	31.27	82.01	726.74	392.13
525	28.12	4208.49	484275.40	31.27	78.58	733.87	395.39
526	28.23	4155.12	480956.50	31.26	72.63	707.45	384.72
527	28.19	4175.06	483851.40	31.27	69.95	714.58	387.98
528	28.26	4138.12	480741.70	31.26	67.86	697.63	380.95
529	28.22	4158.06	483636.30	31.27	65.56	704.76	384.21
530	28.84	3859.63	464731.40	31.24	79.39	685.38	370.51
531	28.75	3902.01	467875.10	31.24	82.70	705.62	378.80
532	28.84	3859.63	464731.40	31.24	79.39	685.38	370.51
533	28.75	3902.01	467875.10	31.24	82.70	705.62	378.80
534	28.51	4012.85	466577.40	31.24	135.31	775.35	405.01
535	28.43	4054.48	469728.00	31.25	132.64	794.90	413.05
536	28.76	3897.38	465183.10	31.24	93.19	707.58	379.02
537	28.70	3925.35	468155.40	31.25	90.37	719.33	384.06
538	28.89	3835.40	464442.80	31.24	70.52	671.12	365.04
539	28.84	3856.75	467333.80	31.24	67.80	679.00	368.59
540	28.17	4182.96	481305.60	31.44	78.97	723.59	390.63
541	28.13	4202.92	484201.50	31.45	75.78	730.72	393.89
542	28.17	4182.96	481305.60	31.44	78.97	723.59	390.63
543	28.13	4202.92	484201.50	31.45	75.78	730.72	393.89
544	28.15	4193.79	481442.30	31.44	82.02	729.86	393.04
545	28.11	4213.80	484339.70	31.45	78.59	736.99	396.30
546	28.22	4160.42	481020.20	31.44	72.64	710.57	385.63
547	28.18	4180.37	483915.40	31.45	69.96	717.70	388.88
548	28.25	4143.42	480805.30	31.44	67.86	700.76	381.85
549	28.21	4163.37	483700.10	31.45	65.57	707.89	385.11
550	28.83	3864.83	464790.10	31.41	79.39	688.50	371.41

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
551	28.73	3907.22	467934.30	31.42	82.70	708.74	379.70
552	28.83	3864.83	464790.10	31.41	79.39	688.50	371.41
553	28.73	3907.22	467934.30	31.42	82.70	708.74	379.70
554	28.50	4018.11	466638.70	31.42	135.32	778.47	405.92
555	28.41	4059.76	469790.40	31.42	132.65	798.02	413.95
556	28.74	3902.59	465242.30	31.41	93.20	710.70	379.92
557	28.68	3930.57	468214.80	31.42	90.37	722.45	384.96
558	28.88	3840.60	464501.20	31.41	70.53	674.24	365.94
559	28.83	3861.95	467392.40	31.42	67.81	682.12	369.50
560	28.19	4172.92	481007.60	31.26	78.94	720.36	389.58
561	28.16	4192.50	483911.40	31.27	75.75	727.49	392.85
562	28.19	4172.92	481007.60	31.26	78.94	720.36	389.58
563	28.16	4192.50	483911.40	31.27	75.75	727.49	392.85
564	28.17	4183.98	481150.60	31.26	81.99	726.64	391.99
565	28.13	4203.56	484054.70	31.27	78.56	733.77	395.27
566	28.24	4149.99	480711.30	31.26	72.61	707.34	384.57
567	28.20	4169.57	483614.70	31.27	69.93	714.47	387.85
568	28.27	4132.70	480488.00	31.26	67.83	697.52	380.79
569	28.23	4152.28	483391.30	31.27	65.54	704.65	384.07
570	28.85	3859.69	464550.80	31.23	79.36	685.30	370.33
571	28.76	3901.65	467701.00	31.24	82.68	705.54	378.64
572	28.85	3859.69	464550.80	31.23	79.36	685.30	370.33
573	28.76	3901.65	467701.00	31.24	82.68	705.54	378.64
574	28.51	4015.76	466485.50	31.24	135.30	775.30	404.91
575	28.43	4056.58	469628.60	31.25	132.63	794.84	412.95
576	28.77	3898.18	465025.30	31.24	93.17	707.51	378.87
577	28.71	3925.43	467995.00	31.24	90.35	719.26	383.91
578	28.91	3834.99	464247.20	31.23	70.50	671.03	364.85
579	28.86	3855.51	467132.30	31.24	67.78	678.91	368.41
580	28.18	4178.31	481075.00	31.44	78.94	723.48	390.48
581	28.15	4197.89	483979.10	31.44	75.76	730.62	393.76
582	28.18	4178.31	481075.00	31.44	78.94	723.48	390.48
583	28.15	4197.89	483979.10	31.44	75.76	730.62	393.76
584	28.16	4189.37	481218.20	31.44	82.00	729.76	392.90
585	28.12	4208.95	484122.50	31.45	78.57	736.90	396.17
586	28.23	4155.38	480778.50	31.44	72.61	710.46	385.48
587	28.19	4174.96	483682.20	31.44	69.94	717.60	388.75
588	28.26	4138.09	480555.30	31.43	67.84	700.64	381.70
589	28.22	4157.67	483458.60	31.44	65.54	707.78	384.98
590	28.84	3864.94	464612.10	31.41	79.37	688.42	371.24
591	28.75	3906.91	467762.60	31.42	82.68	708.66	379.54
592	28.84	3864.94	464612.10	31.41	79.37	688.42	371.24
593	28.75	3906.91	467762.60	31.42	82.68	708.66	379.54
594	28.50	4021.04	466548.30	31.41	135.31	778.42	405.82
595	28.42	4061.86	469691.60	31.42	132.63	797.97	413.86
596	28.75	3903.44	465086.90	31.41	93.18	710.63	379.77
597	28.69	3930.69	468056.80	31.42	90.36	722.38	384.81
598	28.90	3840.23	464308.20	31.41	70.51	674.15	365.76
599	28.85	3860.76	467193.50	31.41	67.79	682.03	369.31

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
600							
601							
602							
603							
604							
605							
606							
607							
608							
609							
610	29.05	3770.16	438310.50	18.81	75.99	458.05	298.79
611	29.04	3776.24	439688.40	18.86	79.43	478.68	306.27
612	29.14	3717.95	436862.10	18.78	75.80	457.23	297.65
613	29.11	3729.01	438392.10	18.84	79.28	477.94	305.26
614	29.50	3574.77	431920.50	15.19	130.85	481.54	308.77
615	29.40	3615.76	434447.10	15.24	128.55	501.64	316.78
616	29.79	3454.89	430417.00	15.18	88.72	413.63	282.71
617	29.72	3482.29	432772.70	15.22	86.27	425.92	287.72
618	29.95	3390.45	429614.40	15.17	66.05	377.09	268.69
619	29.87	3409.53	431875.30	15.22	63.70	385.49	272.23
620	28.11	4216.11	451350.70	22.17	77.67	520.69	325.67
621	28.10	4221.67	452723.80	22.22	80.94	541.30	333.13
622	28.22	4159.91	449535.90	22.13	77.43	519.61	324.16
623	28.19	4170.84	451080.30	22.18	80.75	540.32	331.77
624	28.54	4002.43	444309.50	18.52	132.45	543.53	334.84
625	28.45	4045.91	446953.70	18.57	130.00	563.68	342.95
626	28.81	3877.23	442518.50	18.50	90.27	475.47	308.50
627	28.75	3905.78	444936.00	18.55	87.68	487.79	313.57
628	28.98	3807.16	441500.00	18.49	67.57	438.83	294.28
629	28.93	3828.61	443819.90	18.54	65.08	447.27	297.85
630	27.93	4316.31	453507.50	22.21	77.94	521.80	329.10
631	27.93	4321.41	454868.50	22.26	81.19	542.40	336.55
632	28.02	4260.68	451709.40	22.17	77.71	520.72	327.61
633	28.00	4271.14	453241.20	22.22	81.00	541.43	335.21
634	28.32	4107.32	446655.10	18.56	132.75	544.69	338.39
635	28.24	4149.67	449265.50	18.60	130.27	564.83	346.47
636	28.58	3985.67	444969.80	18.54	90.59	476.70	312.16
637	28.52	4013.69	447372.00	18.59	87.96	489.01	317.22
638	28.72	3919.71	444052.80	18.53	67.90	440.11	298.03
639	28.67	3940.60	446351.50	18.58	65.38	448.53	301.58
640	27.96	4300.51	451917.90	22.16	77.74	520.66	329.43
641	27.95	4305.29	453265.10	22.21	81.01	541.26	336.87
642	28.05	4246.53	450167.80	22.12	77.51	519.62	327.98
643	28.03	4256.54	451681.80	22.18	80.82	540.31	335.56
644	28.34	4099.00	445262.00	18.52	132.57	543.70	338.90
645	28.26	4139.66	447818.60	18.56	130.10	563.80	346.94
646	28.59	3980.93	443693.10	18.51	90.42	475.77	312.77
647	28.53	4008.12	446068.40	18.55	87.81	488.07	317.80
648	28.72	3917.21	442849.70	18.50	67.75	439.22	298.70
649	28.68	3937.66	445135.00	18.54	65.24	447.64	302.24

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
650							
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670	28.69	3925.82	441950.90	21.96	76.46	515.10	317.89
671	28.68	3931.84	443322.10	22.01	79.85	535.71	325.37
672	28.81	3872.28	440207.80	21.93	76.23	514.06	316.45
673	28.79	3883.38	441740.90	21.98	79.67	534.78	324.06
674	29.19	3716.67	434854.70	18.32	131.23	538.11	327.17
675	29.09	3759.23	437455.10	18.37	128.90	558.24	335.24
676	29.46	3601.95	433678.80	18.32	89.14	470.47	301.33
677	29.39	3629.35	436038.20	18.37	86.65	482.75	306.35
678	29.60	3535.66	432808.60	18.32	66.46	433.89	287.26
679	29.56	3556.88	435102.20	18.36	64.07	442.31	290.80
680	28.43	4053.82	445006.10	22.02	76.85	516.73	322.07
681	28.41	4059.23	446362.50	22.07	80.21	537.34	329.53
682	28.54	4000.65	443276.90	21.98	76.63	515.71	320.64
683	28.51	4011.26	444799.80	22.04	80.03	536.41	328.24
684	28.86	3852.12	438189.90	18.38	131.66	539.81	331.54
685	28.77	3893.08	440749.80	18.43	129.28	559.92	339.59
686	29.14	3733.33	436812.10	18.38	89.54	472.06	305.51
687	29.07	3760.95	439184.80	18.42	87.01	484.35	310.55
688	29.30	3668.48	435974.00	18.37	66.86	435.52	291.44
689	29.25	3689.15	438251.90	18.42	64.44	443.93	294.98
690	28.40	4068.48	444379.30	22.00	76.77	516.18	323.20
691	28.38	4073.47	445720.00	22.05	80.13	536.78	330.64
692	28.50	4016.25	442676.30	21.96	76.55	515.18	321.80
693	28.48	4026.39	444181.80	22.01	79.95	535.87	329.38
694	28.82	3871.97	437705.50	18.36	131.60	539.35	332.81
695	28.73	3911.86	440231.00	18.41	129.22	559.44	340.82
696	29.10	3752.26	436124.40	18.35	89.45	471.44	306.62
697	29.04	3779.16	438487.40	18.40	86.93	483.72	311.65
698	29.24	3691.49	435576.30	18.35	66.81	435.10	292.80
699	29.19	3711.82	437846.00	18.40	64.39	443.50	296.33

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
700	27.09	4972.55	522634.90	53.94	86.83	1102.79	505.84
701	27.07	4979.62	522031.10	54.01	88.96	1123.32	513.24
702	27.13	4924.50	520753.20	53.94	86.59	1102.38	504.91
703	27.13	4929.97	520070.80	54.01	88.74	1122.88	512.11
704	27.15	4906.38	515968.90	54.03	141.66	1192.47	536.63
705	27.12	4940.09	516439.60	54.10	138.05	1212.54	544.24
706	27.29	4792.28	514384.10	54.02	99.52	1124.62	510.51
707	27.27	4812.91	514669.00	54.09	95.75	1136.89	515.12
708	27.37	4730.88	513538.30	54.02	76.84	1088.12	496.46
709	27.35	4744.97	513730.90	54.09	73.18	1096.52	499.58
710	27.20	4866.82	518043.20	53.89	86.24	1100.88	502.95
711	27.20	4867.27	517176.40	53.95	88.40	1121.34	510.04
712	27.26	4813.72	515968.90	53.89	85.98	1100.42	501.75
713	27.26	4818.51	515257.50	53.95	88.18	1120.91	508.94
714	27.29	4795.60	511114.90	53.97	141.04	1190.47	533.44
715	27.25	4828.98	511565.30	54.04	137.48	1210.53	541.04
716	27.43	4682.09	509573.90	53.97	98.90	1122.64	507.34
717	27.40	4702.60	509850.30	54.04	95.19	1134.90	511.95
718	27.64	4514.58	507435.60	53.96	76.05	1085.81	488.98
719	27.62	4528.80	507626.20	54.03	72.47	1094.20	492.09
720	27.02	5038.69	525298.40	55.96	87.18	1139.31	516.85
721	27.01	5040.13	524472.60	56.02	89.25	1159.78	523.96
722	27.06	4990.20	523397.50	55.95	86.93	1138.90	515.90
723	27.05	4996.13	522734.80	56.02	89.05	1159.40	523.11
724	27.08	4971.95	518618.00	56.04	142.00	1228.99	547.63
725	27.04	5005.65	519091.00	56.11	138.35	1249.07	555.24
726	27.21	4857.99	517030.00	56.04	99.86	1161.15	521.51
727	27.19	4878.61	517316.20	56.11	96.06	1173.42	526.12
728	27.29	4796.57	516178.50	56.03	77.18	1124.65	507.46
729	27.27	4810.68	516373.20	56.10	73.48	1133.04	510.58
730	27.08	4971.94	522381.70	55.92	86.80	1138.09	515.06
731	27.08	4973.18	521547.30	55.99	88.91	1158.56	522.17
732	27.14	4918.45	520287.00	55.92	86.53	1137.62	513.85
733	27.13	4923.80	519599.50	55.99	88.68	1158.12	521.05
734	27.16	4900.21	515463.40	56.01	141.60	1227.70	545.56
735	27.12	4933.76	515925.90	56.08	137.99	1247.77	553.17
736	27.30	4786.70	513906.90	56.00	99.45	1159.86	519.46
737	27.27	4807.22	514186.70	56.07	95.70	1172.13	524.07
738	27.37	4725.67	513078.70	56.00	76.78	1123.37	505.42
739	27.35	4739.70	513268.20	56.07	73.12	1131.76	508.54
740	27.13	4932.44	520677.00	55.90	86.58	1137.39	513.93
741	27.12	4933.32	519827.80	55.97	88.71	1157.86	521.04
742	27.19	4879.04	518587.90	55.90	86.31	1136.92	512.72
743	27.18	4884.23	517893.30	55.97	88.49	1157.42	519.92
744	27.21	4860.78	513737.20	55.99	141.38	1226.99	544.43
745	27.17	4894.33	514198.20	56.06	137.79	1247.05	552.03
746	27.35	4747.43	512194.40	55.98	99.23	1159.16	518.33
747	27.32	4767.95	512473.10	56.05	95.50	1171.43	522.94
748	27.42	4686.37	511368.30	55.98	76.56	1122.66	504.29
749	27.40	4700.38	511556.60	56.05	72.92	1131.06	507.41

SHIP NUM	VS	DIS	INTVOL	WTG2 /SHP	WTG3 /KW	WTG2+ WTG3	COST
750	27.10	4954.65	522537.70	53.16	86.82	1088.75	502.02
751	27.10	4955.82	521700.60	53.22	88.93	1109.22	509.13
752	27.16	4900.98	520435.20	53.15	86.55	1088.28	500.80
753	27.16	4906.31	519746.60	53.22	88.70	1108.78	508.01
754	27.18	4882.80	515644.60	53.24	141.62	1178.36	532.52
755	27.14	4916.51	516114.00	53.31	138.01	1198.43	540.13
756	27.32	4768.87	514070.80	53.24	99.48	1110.52	506.41
757	27.29	4789.49	514354.80	53.30	95.71	1122.79	511.02
758	27.39	4707.48	513227.50	53.23	76.80	1074.01	492.36
759	27.38	4721.58	513420.00	53.30	73.14	1082.41	495.48
760	27.23	4843.32	517728.80	53.10	86.20	1086.78	498.84
761	27.23	4843.64	516856.30	53.17	88.37	1107.24	505.94
762	27.29	4790.31	515659.60	53.10	85.94	1086.32	497.65
763	27.29	4795.07	514946.40	53.17	88.14	1106.81	504.84
764	27.31	4772.14	510799.40	53.19	141.00	1176.36	529.34
765	27.27	4805.70	511256.60	53.26	137.45	1196.43	536.94
766	27.59	4550.61	507857.10	53.18	98.68	1108.16	498.86
767	27.57	4571.32	508134.30	53.24	94.99	1120.42	503.45
768	27.67	4491.08	507132.00	53.17	76.02	1071.71	484.90
769	27.65	4505.23	507319.70	53.24	72.43	1080.10	488.00
770	27.00	5049.08	525443.30	56.30	87.20	1145.48	518.65
771	27.00	5050.58	524619.70	56.37	89.26	1165.95	525.76
772	27.05	5000.48	523537.70	56.30	86.95	1145.06	517.69
773	27.04	5006.49	522877.90	56.37	89.06	1165.57	524.91
774	27.07	4982.24	518760.40	56.39	142.02	1235.17	549.42
775	27.03	5015.94	519234.00	56.46	138.37	1255.24	557.04
776	27.20	4868.17	517165.60	56.38	99.87	1167.32	523.31
777	27.18	4888.86	517455.00	56.45	96.07	1179.59	527.92
778	27.27	4806.83	516316.40	56.38	77.20	1130.82	509.26
779	27.26	4820.93	516511.00	56.45	73.50	1139.21	512.38
780	27.09	4976.47	522294.20	56.26	86.79	1144.20	516.57
781	27.07	4983.54	521689.70	56.33	88.93	1164.73	523.97
782	27.13	4928.68	520423.70	56.26	86.55	1143.79	515.64
783	27.12	4934.10	519739.10	56.33	88.70	1164.29	522.85
784	27.15	4910.40	515599.70	56.35	141.62	1233.87	547.36
785	27.11	4943.88	516060.20	56.42	138.00	1253.93	554.96
786	27.28	4797.02	514047.20	56.35	99.47	1166.04	521.26
787	27.26	4817.54	514327.20	56.41	95.71	1178.30	525.87
788	27.36	4735.92	513215.50	56.34	76.80	1129.54	507.21
789	27.34	4749.96	513405.80	56.41	73.14	1137.93	510.33
790	27.11	4942.72	520815.50	56.25	86.60	1143.56	515.73
791	27.11	4943.67	519969.30	56.31	88.73	1164.02	522.83
792	27.18	4889.28	518724.30	56.24	86.33	1143.09	514.52
793	27.17	4894.52	518032.00	56.31	88.50	1163.59	521.72
794	27.20	4871.09	513878.40	56.33	141.39	1233.16	546.22
795	27.16	4904.64	514339.80	56.40	137.80	1253.22	553.83
796	27.33	4757.56	512326.30	56.33	99.25	1165.32	520.12
797	27.31	4778.09	512605.30	56.39	95.51	1177.59	524.73
798	27.41	4696.49	511498.80	56.32	76.58	1128.83	506.08
799	27.39	4710.51	511687.50	56.39	72.94	1137.22	509.20

APPENDIX III

COPY OF FORTRAN PROGRAM

```
      INTEGER N1,N2,N3,N4,N,I,STRDOM,SIGDOM,L,L1,L2,P,N5,N6
      INTEGER M, CHECK, CHECK1, CHECK2, STRNUM, SIGNUM
      REAL S(800,15),W(15),B(15),CASE(15),TEMP(15)
      REAL STRICT(800), COMSTR(200)
      REAL SIGNIF(800), COMSIG(200)
      CHARACTER*1 A1
C
C
      OPEN(15,FILE=' ')
      OPEN(16,FILE=' ')
C
C INITIALIZE THE ARRAY SIZE AND ANALYST COMPARISION VALUES
C
      WRITE( *,900)
 900  FORMAT(' INPUT LENGTH OF DATA ARRAY (MAX=800) ')
      READ (*,901) N1
 901  FORMAT (I3)
      WRITE( *,902)
 902  FORMAT(' INPUT WIDTH OF DATA ARRAY (MAX=15) ')
      READ (*,903) N2
 903  FORMAT (I2)
      WRITE (*,904)
 904  FORMAT (' INPUT COLUMN NUMBER OF LAST COLUMN OF
     1OPTIONS')
      READ (*,903) N3
      N4=N3+1
      WRITE (*,905)
 905  FORMAT(' INPUT MUCH WORSE VALUE FOR EACH ATTRIBUTE')
      READ (*,*) (W(I), I=N4,N2)
      WRITE(*,906)
 906  FORMAT(' INPUT NOT SIGNIFICANTLY BETTER VALUE FOR
     1EACH ATTRIBUTE')
      READ (*,*) (B(I), I=N4,N2)
C
C
      DO 100 L=1,800
         DO 101 L1=1,15
            S(L,L1)=0.0
 101     CONTINUE
         STRICT(L)=0.0
         SIGNIF(L)=0.0
 100  CONTINUE
      DO 102 L=1,200
         COMSTR(L)=0.0
         COMSIG(L)=0.0
 102  CONTINUE
      CHECK=0
      CHECK1=0
      CHECK2=N2
C
      DO 103 N=1,N1
         READ (15,*) (S(N,I), I=1,N2)
 103  CONTINUE
```

```
C
 601  WRITE (*,907)
 907  FORMAT (' DO ANY ATTRIBUTES NEED TO BE INVERTED
     1(Y/N) ? ')
      READ (*,969) A1
 969  FORMAT (A)
      IF (A1 .NE. 'Y') GOTO 508
      WRITE (*,908)
 908  FORMAT (' INPUT THE COLUMN NUMBER TO BE INVERTED ')
      READ (*,903) M
      WRITE (*,909)
 909  FORMAT (' INPUT THE NUMERATOR FOR THE INVERSION ')
      READ (*,910) P
 910  FORMAT (I7)
      DO 287 I=1,N1
         S(I,M)=P/S(I,M)
 287  CONTINUE
      GOTO 601
C
C
 508  L1=0
      L2=0
C
C
      DO 200 I=1,N1
         DO 210 M=1,N2
            TEMP(M)=S(I,M)
 210     CONTINUE
         STRDOM=1
         SIGDOM=1
         DO 220 M=1,N1
            IF (STRDOM .EQ. 1) THEN
               DO 230 L=N4,N2
               IF (TEMP(L) - S(M,L) .LE. 0) GOTO 300
 230           CONTINUE
               STRDOM=0
 300           CONTINUE
            ENDIF
            IF (SIGDOM .EQ. 1) THEN
               DO 240 L=N4,N2
               IF (TEMP(L) - S(M,L) .GE. W(L)) GOTO 310
 240           CONTINUE
               GOTO 320
 310           DO 250 P=N4,N2
               IF (S(M,P) - TEMP(P) .GE. B(P)) GOTO 320
 250           CONTINUE
               SIGDOM=0
 320           CONTINUE
            ENDIF
            IF ((STRDOM .EQ. 0) .AND. (SIGDOM .EQ. 0)) GOTO
     1      350
 220     CONTINUE
         IF (STRDOM .EQ. 0) GOTO 340
```

```
          L1=L1+1
          STRICT(L1)=I
 340    IF (SIGDOM .EQ. 0) GOTO 350
          L2=L2+1
          SIGNIF(L2)=I
 350    CONTINUE
 200  CONTINUE
C
C
      IF (CHECK1 .EQ. 1) GOTO 401
      IF (L1 .EQ. 0) GOTO 390
        DO 280 I=1,L1
          M=STRICT(I)
          WRITE (16,950) (S(M,N), N=1,15)
 280    CONTINUE
 390  IF (L2 .EQ. 0) GOTO 401
        DO 290 I=1,L2
          M=SIGNIF(I)
          WRITE (16,950) (S(M,N), N=1,15)
 290    CONTINUE
 950  FORMAT (15(F9.2,2X))
C
C
      N5=L1
      N6=L2
 565    P=STRICT(1)
        TEMP(1)=S(P,N3)
        DO 562 N=1,N5
          M=STRICT(N)
          IF (TEMP(1) .NE. S(M,N3)) GOTO 564
 562    CONTINUE
        DO 563 N=1,N6
          M=SIGNIF(N)
          IF (TEMP(1) .NE. S(M,N3)) GOTO 564
 563    CONTINUE
        WRITE (16,953) TEMP(1), N3
 953    FORMAT (' OPTION ',F3.1,' IN COLUMN ',I2,' IS
     1  DOMINANT')
        N3=N3-1
        IF (N3 .EQ. 1) GOTO 574
        GOTO 565
 564    TEMP(1)=S(1,N3)
        DO 566 N=1,N1
          IF (TEMP(1) .EQ. S(N,N3)) GOTO 566
          DO 567 P=1,N5
            M=STRICT(P)
            IF (TEMP(1) .EQ. S(M,N3)) GOTO 576
 567      CONTINUE
          DO 568 P=1,N6
            M=SIGNIF(P)
            IF (TEMP(1) .EQ. S(M,N3)) GOTO 576
 568      CONTINUE
          WRITE (16,954) TEMP(1), N3
```

```
954         FORMAT(' OPTION ',F3.1,' IN COLUMN ',I2,' IS
     1      INFERIOR')
576         TEMP(1)=S(N,N3)
566       CONTINUE
          N3=N3-1
          IF (N3 .EQ. 1) GOTO 574
          GOTO 565
574       N3=N4-1
C
C
401    IF (L1 .EQ. 1) GOTO 637
       DO 201 I=1,L1
          P=STRICT(I)
          DO 211 M=1,N2
             TEMP(M)=S(P,M)
211       CONTINUE
          DO 221 M=2,L1
             IF (I .EQ. M) GOTO 221
             P= STRICT(M)
             DO 223 L3=1,N2
                CASE(L3)=S(P,L3)
223          CONTINUE
             DO 231 L=N4,N2
                IF(W(L) .LT. ABS(TEMP(L)-CASE(L))) GOTO 500
231          CONTINUE
             STRICT(M)=0.0
500          CONTINUE
221       CONTINUE
201    CONTINUE
       M=1
       DO 261 I=2,L1
          IF(STRICT(I) .EQ. 0) GOTO 261
          M=M+1
          STRICT(M)=STRICT(I)
261    CONTINUE
       L1=M
       M=M-1
       IF (STRICT(M) .EQ. STRICT(L1)) L1=M
C
C
637    IF (L2 .EQ. 1) GOTO 638
       DO 202 I=1,L2
          P=SIGNIF(I)
          DO 212 M=1,N2
             TEMP(M)=S(P,M)
212       CONTINUE
          DO 222 M=2,L2
             IF (I .EQ. M) GOTO 222
             P=SIGNIF(M)
             DO 233 L3=1,N2
                CASE(L3)=S(P,L3)
233          CONTINUE
             DO 232 L=N4,N2
```

```
               IF(W(L) .LT. ABS(TEMP(L)-CASE(L))) GOTO 502
  232        CONTINUE
             SIGNIF(M)=0.0
  502        CONTINUE
  222     CONTINUE
  202  CONTINUE
       M=1
       DO 262 I=2,L2
          IF(SIGNIF(I) .EQ. 0) GOTO 262
             M=M+1
             SIGNIF(M)=SIGNIF(I)
  262  CONTINUE
       L2=M
       M=M-1
       IF (SIGNIF(M) .EQ. SIGNIF(L2)) L2=M
C
C
  638  IF(CHECK .EQ. 1) GOTO 503
          DO 203 I=1,L1
             COMSTR(I)=STRICT(I)
  203     CONTINUE
          DO 204 I=1,L2
             COMSIG(I)=SIGNIF(I)
  204     CONTINUE
          CHECK=1
          STRNUM=L1
          SIGNUM=L2
  503  DO 205 I=1,L1
          P=STRICT(I)
          WRITE(16,950)  (S(P,N), N=1,15)
          STRICT(I)=0.0
  205  CONTINUE
       DO 206 I=1,L2
          P=SIGNIF(I)
          WRITE(16,950)  (S(P,N), N=1,15)
          SIGNIF(I)=0.0
  206  CONTINUE
  403  IF(CHECK1 .EQ. 0) GOTO 505
C
C
       IF((L1 .NE. STRNUM) .OR. (L2 .NE. SIGNUM)) GOTO 504
          WRITE(16,951) CHECK2
  951  FORMAT(' COLUMN ',I2,' IS REDUNDANT')
C
C
  504  IF(CHECK1 .EQ. 0) GOTO 505
       CHECK2=CHECK2-1
       IF(CHECK2 .EQ. N3) GOTO 400
       N2=N2+1
       DO 207 I=1,N1
          TEMP(1)=S(I,N2)
          S(I,N2)=S(I,CHECK2)
          S(I,CHECK2)=TEMP(1)
```

```
207   CONTINUE
      N2=N2-1
      GOTO 636
505   N2=N2-1
      CHECK1=1
      IF(N2 .EQ. N3) GOTO 400
636   DO 634 I=1,N1
         STRICT(I)=0.0
         SIGNIF(I)=0.0
634   CONTINUE
      GOTO 508
400   CONTINUE
      CLOSE(15,STATUS='KEEP')
      CLOSE(16,STATUS='KEEP')
STOP
END
```